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Inspired Conservation

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InspIred ConservatIon

A Design Thesis submitted to the
Department of Architecture and Landscape Architecture
of North Dakota State University

In Partial Fulfillment of the
Requirements for the Degree of
Masters of Architecture

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05/04/2012

Primary Thesis Advisor

Thesis Committee Chair

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PART I | STATEMENT OF INTENT

THESIS ABSTRACT

This thesis aims to achieve higher levels of building performance by instilling a consciousness toward energy conservation in inhabitants of a built construct. A variety of methods for harnessing, storing, and using energy are available today; however, because conventional energy is non-renewable and harmful to the environment, architects must continually explore renewable energy and integrate appropriate passive/active strategies in early stages of design to lessen the dependency and use of these resources. In response, this proposal for a mixed-use building will become an expression of energy conservation while serving as an extension of St. Paul's transportation and energy infrastructure, and preserving the city's historical significance.

TYPE

Class:	Mid-Rise
Typology	Mixed-Use
Site Location	St. Paul, MN
Stories	20
Site Area	2,635m^2 (28,363ft^2)
Foot Print	1,375m^2 (14,800ft^2)
Total Area	15,963m^2 (171,825ft^2)

MATERIALS

Super Structure	Steel Wide Flange
Sub Structure	Steel Wide Flange
	Steel Lintel
Floor Plates	Hollow Core Concrete
Envelope	Prefabricated Brick Panels
	Aluminium Panels
	Triple & Double Pane Glazing
	White Reflective Coating
Interior Finishes	Raised Wood Flooring
	Ceramic Tile Flooring
	Drop Gypsum Ceiling
	Gypsum & Brick Walls

SYSTEMS USED

- Distric Energy (Heating & Cooling)
- Solar Chimney (Passive Ventilation)
- Liquid Thermal Storage
- Dye Sensitized Solar Cells (DSSC)
- 26kw Silicon Photovoltaic Array
- Central HVAC
- 500mm X 250mm Ducts (3 ACH)
- Local Fan Coil Units
- Green & Reflective Roof

SYSTEMS EXPLORED (unused)

- Double Envelope
- Integrated Wind Generators
- Underfloor Heating
- Geothermal
- Raised Floor

PROBLEM STATEMENT

How can architecture become an expression which inspires people to conserve energy?

"This intolerable dependence on foreign oil threatens our economic independence and the very security of our nation. The energy crisis is real. It is worldwide. It is a clear and present danger to our nation. These are facts and we simply must face them."

| *Jimmy Carter, 39th U.S. President*

STATEMENT OF INTENT

TYPOLOGY

Low-Energy, Mixed-Use Complex

CLAIM

Energy is essential for performing daily rituals in modern society; and despite growth in energy consumption, our culture is still dependent on conventional and foreign energy. To claim back that independence on energy through architecture, there must be a constant exploration of passive/active strategies in all stages of design, and the inhabitants who occupy these buildings must be moved to conserve on energy resources.

PREMISES

Designers must consider a "whole-building" design approach while pursuing energy goals. (USGBC)

Architecture must perform as closely as intended while inspiring individuals to practice energy conservation.

Owners must provide the main motivation for low energy buildings by setting energy saving goals.

THEORETICAL PREMISE

High Performance buildings are achieved not only through the exploration of both passive & active systems in early stages of design, but by adapting & changing these systems as the design evolves. All components and objectives of the design must be held in proper balance throughout the design process as spaces and form begin to take shape.

PROJECT JUSTIFICATION

It is imperative that there is an understanding of the relationship between daily ritual, energy consumption, and where energy comes from. That is why this thesis aims to contribute to the field of energy technology in architecture. Public awareness of such possibilities will promote exploration and innovation within this intricate connection between energy and architecture.

PART II | PROPOSAL

“Someday, humankind will harness the rise and fall of the tides, imprison the power of the sun, and release atomic power”

| *Thomas Edison*

THE NARRATIVE

The Industrial Revolution marks a place in history which has significantly altered how people live. Toward the end of this period, Thomas Edison invented the light bulb. Shortly after, in 1882, with one flick of a switch, 52 bulbs went on in the offices of the New York Times (Yergin, 2011). The electricity which flowed through the filament in those bulbs originated from a coal powered electric plant which Edison had built, and from that moment changed the way people use energy.

Today, electricity powers everything in buildings from light bulbs to environmental control systems. However before it reaches its designated appliance, this energy must travel great distances from its origin, typically an off site coal or nuclear plant, which reduces the initial efficiency of electricity to as low as 20%. Electricity is considered a secondary source of energy, a by-product of primary fuels such as coal, oil (petroleum), natural gas, and uranium (nuclear), all of which can have environmental ramifications such as landscape alteration, environmental contamination, greenhouse gas emissions, etc.

Renewables are said to be the solution to these environmental and energy challenges. However products such as silicon solar cells and wind generators contain a significant amount of embodied energy, or the measure of the total energy consumed by a product during its life or complete life cycle from harvesting raw materials to manufacture, transportation, installation, and in some cases recycling (AIA). To lower this figure, owners and architects must select local manufacturers, and the manufacturing companies must be as efficient and transparent as possible so consumers can make responsible selections.

Investing in local energy alternatives is a step toward boosting the local economy, conserving global resources, and preserving the environment. However, people must still learn to use these alternatives in responsible ways. This means that the importance of energy conservation must be instilled in every aspect of people’s lives, and architects must continue to explore passive and active strategies throughout building design stages.

“The dialogue between client and architect is about as intimate as any conversation you can have, because when you’re talking about building a house, you’re talking about dreams.”

| *Robert A. M. Stern*

USER/CLIENT DESCRIPTION

OWNER

If Apartments:
This mixed-use complex will be owned by a real estate investor whose main motivation is low-energy. It will be maintained and operated by a licensed real estate management company.

If Condominiums:
This mixed-use complex will be owned by a real estate investor, and commercial space will be leased out to small businesses. The condominiums will be maintained and operated by a board of directors or a licensed management company.

USERS

| Residents especially attracted to the practice of energy conservation.
| Commuters seeking downtown parking adjacent the skyway and public transportation system.
| Small business owners interested in bringing business to a high pedestrian junction.
| Patrons looking for local goods and services.

"I'm asking you for your good and for your nation's security to take no unnecessary trips, to use carpools or public transportation whenever you can, to park your car one extra day per week, to obey the speed limit, and to set your thermostats to save fuel. Every act of energy conservation like this is more than just common sense; I tell you it is an act of patriotism."

| *Jimmy Carter, 39th U.S. President*

MAJOR PROJECT ELEMENTS

LIVING SPACE

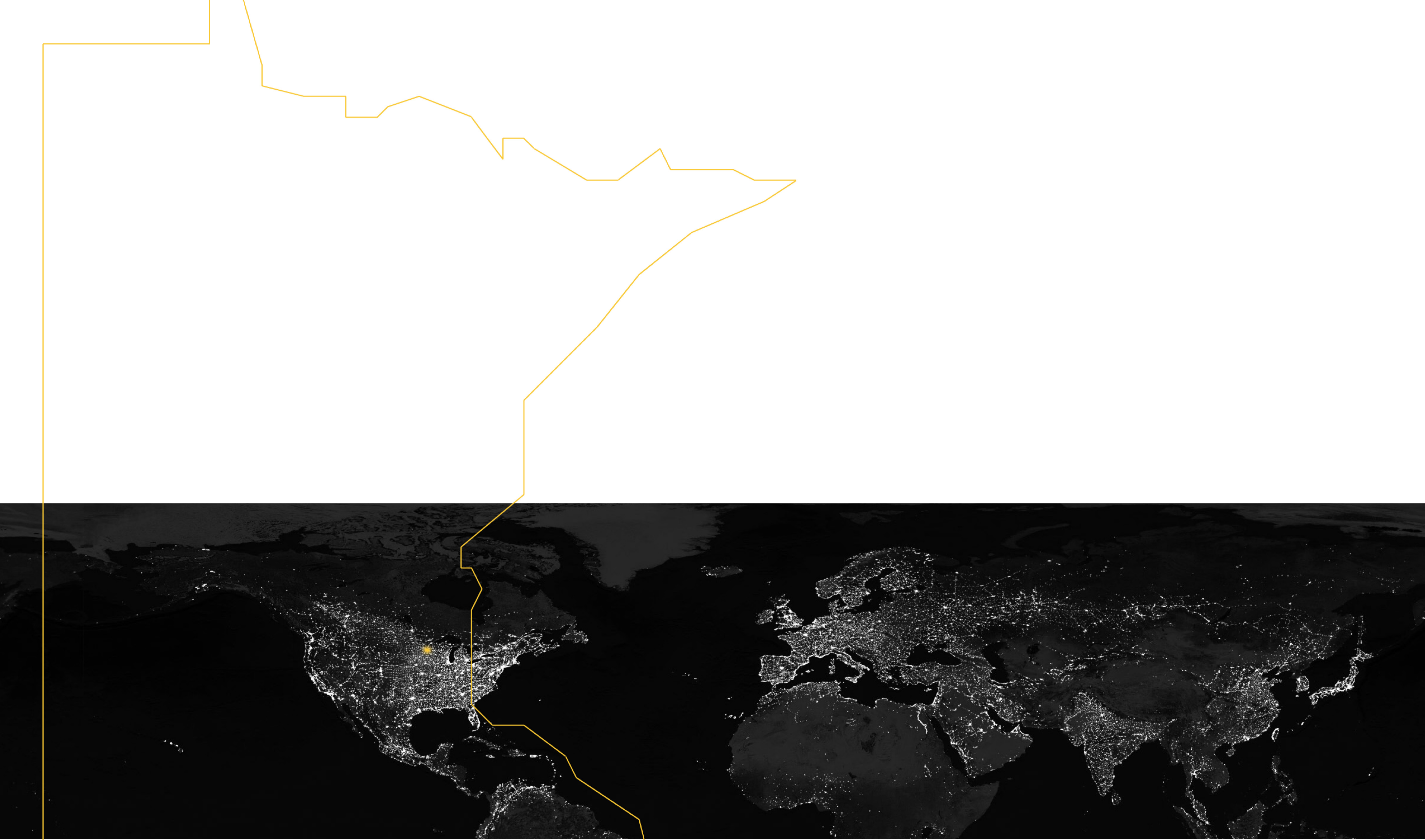
These spaces will be a residence for those seeking to dwell within the practice of energy conservation and enjoy the conveniences of local markets, public transportation, restaurants, and other amenities provided by the downtown St. Paul area.

COMMERCIAL SPACE

These spaces will serve as market and retail for local communities once the LRT and AmTrak lines open for public use. Commercial space will be leased out to small business owners who want to take advantage of the marketing and sales opportunities at this high pedestrian junction.

SKYWAY

This space will be a bridge between the proposed building and the Union Depot terminal, providing access to St. Paul's extensive skyway network.



St. Paul, MN | Lat 44.93, Long 93.05 |

REGION

The Mid-West climate will demonstrate the use and performance of alternative energy under a wide variety of daylight hours and weather conditions over the course of a year.

CITY

St. Paul is home to District Energy, an energy plant that uses (renewable) biomass for fuel to heat and cool buildings in the downtown area, which eliminates the need for boilers, chillers, or cooling towers.

SITE

The Mississippi River and commercial rail lie directly south of the site, which will provide future development permanent solar and wind access. The site also offers views of the Mississippi River to the south, St. Paul's tremendous skyline to the west, and historical bridge structures down river.

MAJOR LANDMARKS

- District Energy Biomass Plant
- Union Depot Station
- Mississippi River
- St. Paul Cathedral
- River Centre
- 1st National Bank Building
- Farmers Market
- Grand Avenue
- Science Museum
- Light Rail Transit
- MS River Trail
- State Capitol
- Galtier Plaza
- Wells Fargo Plaza
- Mears Park
- Robert St. Bridge

PROJECT EMPHASIS

THEORETICAL PREMISE (*REVISITED*)

High Performance buildings are achieved not only through the exploration of both passive & active systems in early stages of design, but by adapting & changing these systems as the design evolves. All components and objectives of the design must be held in proper balance throughout the design process as spaces and form begin to take shape.

EMPHASIS

This thesis will pursue a whole building design approach and seek past and present innovations in energy systems & technology to determine the role it plays in shaping how people live. The development of a community where participatory action is taken to conserve energy will be the ideal outcome. This will require providing occupants with choice; the judgement when to use renewable and non-renewable energy, the ability to take public transportation at the same convenience as a motor vehicle, the responsibility of selecting local over foreign products, and the decision to turn off the light in a room where it is not being used.

PLAN FOR PROCEEDING

RESEARCH DIRECTION

Research will follow the theoretical premise, research & development of energy technologies, site and typology history, site analysis, and programming.

DESIGN METHODOLOGY

Research will follow a mixed method approach where both quantitative and qualitative data are documented simultaneously. A whole-building design methodology will be implemented.

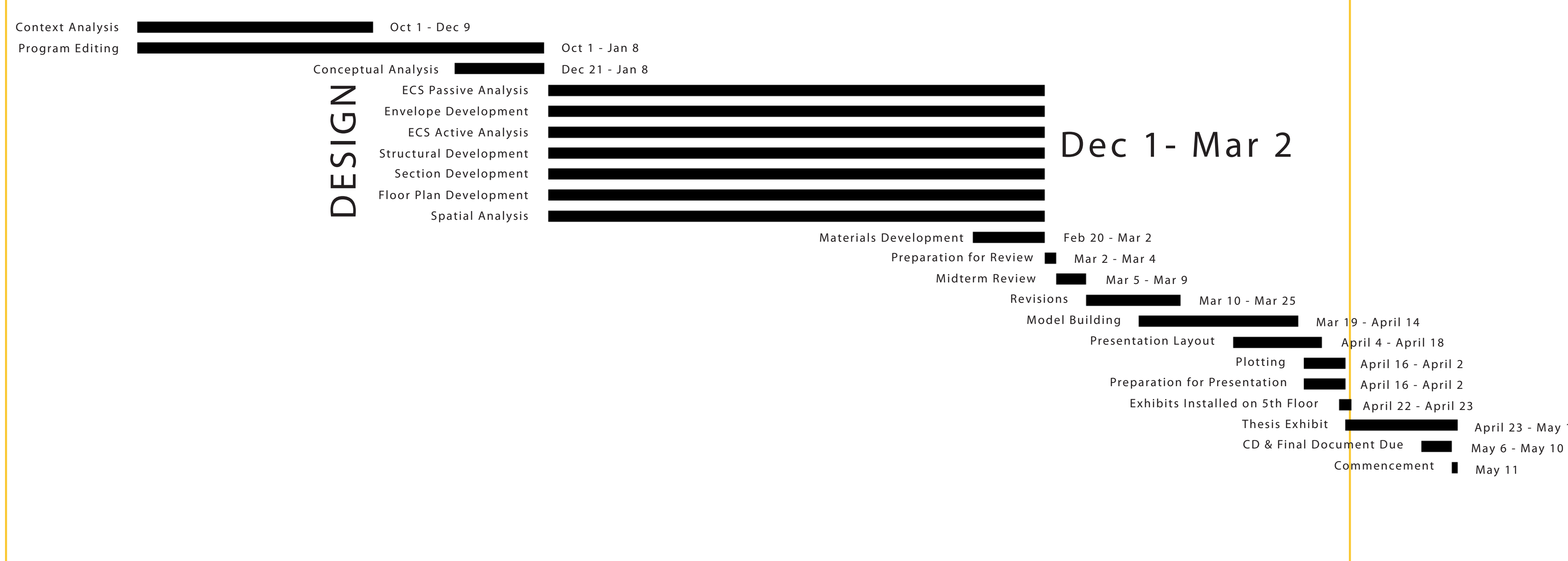
DOCUMENTING THE DESIGN PROCESS

All research and design work will be assembled into a digital format and backups will be made regularly. On a biweekly basis, all current documentation will be assembled so advisor(s) can evaluate the research progress. All final digital and physical documentation will be made available in an online digital repository for public viewing, and all findings will be displayed for a final critique.

“Time is really the only capital that any human being has and the thing that they can least afford to waste or lose”

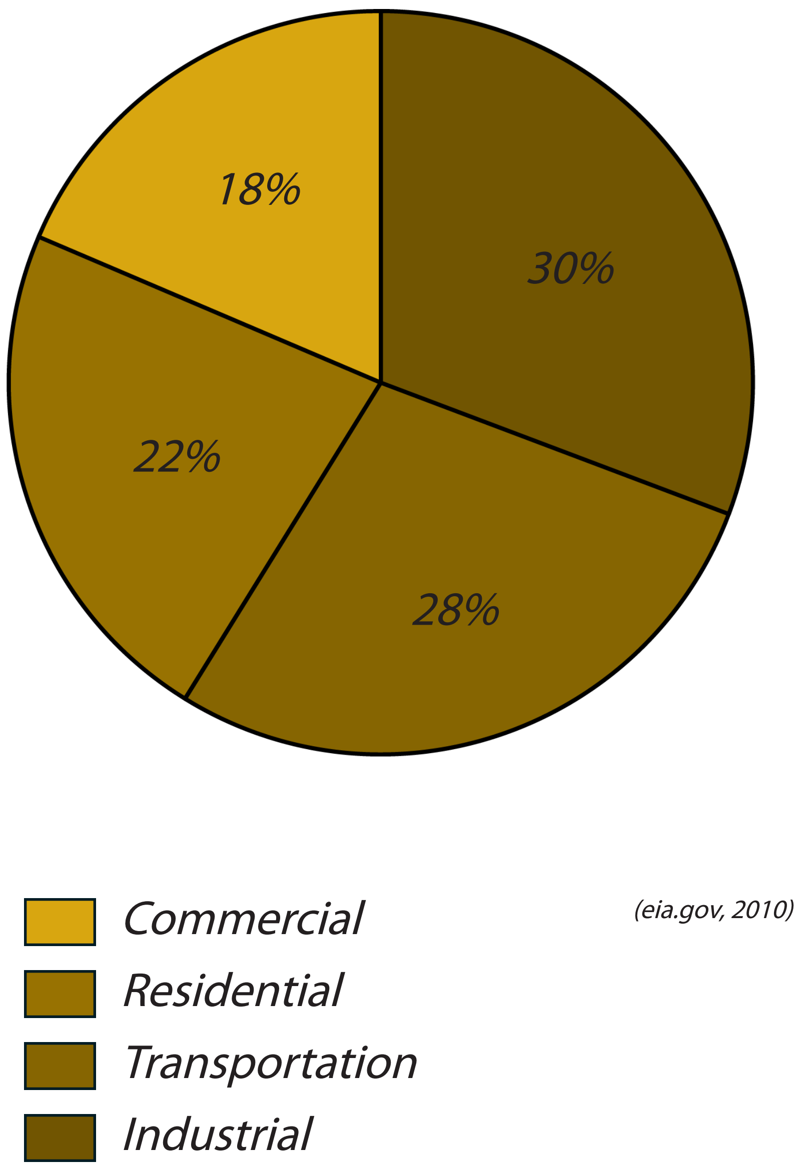
Thomas Edison

THESIS SCHEDULE | Oct 1-May 11



PART III | PROGRAM

U.S. Energy Consumption by Sector
2010



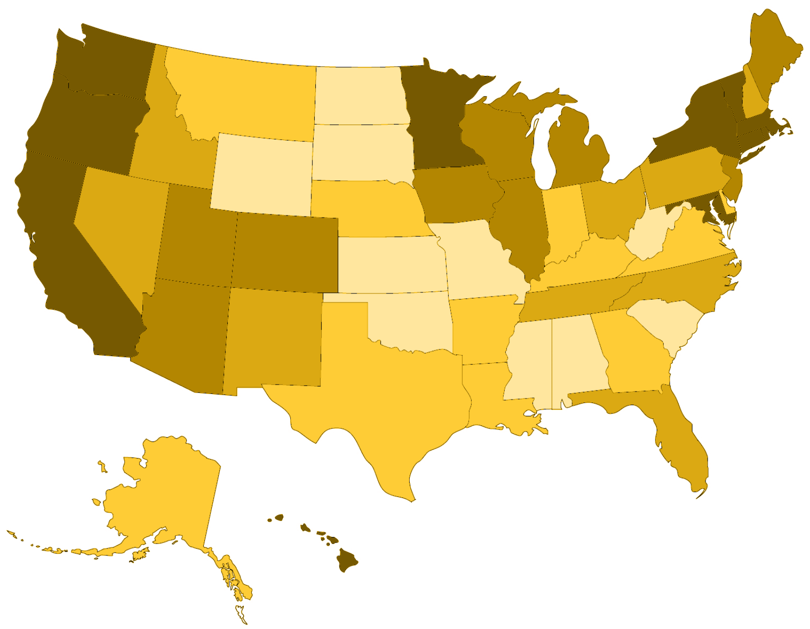
In the United States today, buildings account for 36% of total energy use and 65% of electricity consumption. Of this electricity, 71% is generated using nonrenewable resources, and because there is a limited amount of these energy sources on Earth, it is important to conserve the current supply and use renewable sources so that natural resources will be available for future generations. (EPA, 1997).

A building's energy performance is not entirely dependent on the people who design and build it. It is the owner's responsibility to provide the main motivation for low-energy-buildings by setting measurable and aggressive energy saving goals at the beginning of the project (Torcellini 2006). This provides a foundation for appropriate design strategies, systems, and construction methods for architects, engineers, contractors, etc.

In whole building design, a design team identifies goals early in the design process. This methodology and approach requires all aspects of a high performance building, such as structure, mechanical, space, form, materials, etc., to be designed and integrated simultaneously and with equal importance. This requires using energy analysis software and simulations which can perform trade-off analysis to examine energy impacts of architecture choices and HVAC&L (heating, ventilation, air-conditioning, and lighting) designs (Torcellini 2006).

Energy technology is always advancing in both renewable and non-renewable sectors. It is the architect's responsibility to determine how the building can be powered for that particular region and site, and to inform the owner of the performance and cost of each. State-of-the-art technology can greatly alter and control parameters of building performance; however, there must still be an estimate of the building's energy load to determine appropriate strategies and systems. Even if all energy goals are met, energy performance is still dependent on occupancy.

State Energy Efficiency Ranking
2011



Rank 1-10
Rank 11-20
Rank 21-30
Rank 31-40
Rank 41-50

(aceee.org, 2011)

Note: Government incentives and rebates are regularly subject to change. For up to date information visit www.dsireusa.org

(Database of State Incentives f or Renewables & Efficiency)

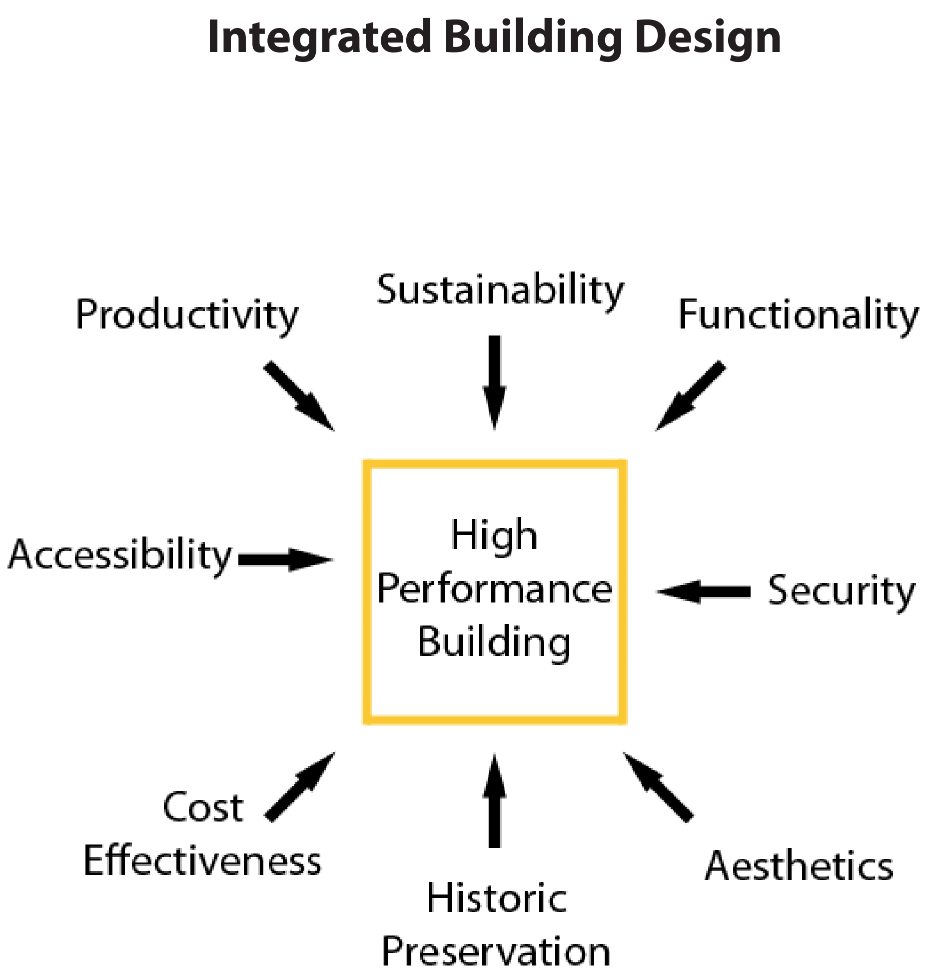
People understand that conserving energy, between turning off the lights or purchasing energy star-rated appliances, is in their best interest in the long run, financially & environmentally. They are generally interested in and plan on investing in energy efficient products and behaviors, but normally do not follow through. Among many factors, people require incentives and non-price interventions to guide them toward that commitment (Dr. Hunt Allcott 2010 pg 1).

According to the EPA (Environmental Protection Agency), energy demand continues to grow despite historically high energy prices and mounting concerns over energy security and independence as well as air pollution and global climate change. In Response, the Federal Government has provided individuals and businesses with energy bonds and tax credits as an incentive to purchase alternative energy systems and energy efficient appliances to help alleviate the national demand for energy.

In 2004, the state of Minnesota launched the Minnesota Solar Electric Rebate in which a certified photovoltaic system can receive 1.75% per watt, a $8,750 maximum rebate. In 2006, the governor of Minnesota, Tim Pawlenty, signed a renewable energy bill that requires 25% of Minnesota's energy to come from renewable sources by 2025. Excel Energy, Minnesota's electric utility company, responded by establishing a rewards programs which allows up to a 40 kW grid-connected solar photovoltaic system to receive an up-front rebate of $2.25 per watt of DC (direct current) electricity. The energy that a customer does not utilize from their system is put into the grid to compensate for peak usage during the day.

Even though energy efficiency is an integral component of energy conservation, it also requires active participation by individuals to monitor and conserve their energy use by walking and cycling to destinations which are nearby, utilizing public transportation, air drying clothes, turning off the lights, etc. People must be provided with these opportunities, or rather presented with the choice to conserve energy.

ENERGY EFFICIENCY + ACTIVE PARTICIPATION = ENERGY CONSERVATION



(Prowler, Vierra & Winter, 2011)

Buildings in today's technologically advanced world are incredibly complex, and in many cases require people from varying disciplines to design them. Whole building design is about merging varying professions and good design principles simultaneously during the programming and design phases of a building. Unlike conventional methods where a project is handed from person to person, it requires multidisciplinary collaboration which emphasizes the development of a "holistic design." A design which works together as a system of systems from conception to completion. The goal and preferred outcome of such an integrated design process is a high performance building.

A high-performance building can be achieved if all components and objectives of the design are held in proper balance throughout the design process, and if their interrelationships and interdependencies with all building systems are understood, evaluated, appropriately applied, and coordinated concurrently from the planning and programming phase.(Prowler, Vierra, & Winter 2011)

Accessibility	addressing the needs of disabled persons
Aesthetics	composing delightful visual elements
Cost Effectiveness	considering appropriate design alternatives
Functionality	developing functional programming
Historic Preservation	conserving historic buildings and districts
Productivity	providing physical and psychological comfort
Security	providing occupants with physical protection
Sustainability	enhancing the performance of elements and strategies

The Leed Rating System is becoming nationally recognized, and even though many buildings do not apply for Leed certification, many clients still require that this particular standard is carried out through design and construction phases. The 2012 update of this rating system will begin to focus on the Integrated Design Process, awarding credit for project teams holding charrettes, team meetings and conducting a thorough site assessment (Sims, 2012).

BIM: a digital representation and shared knowledge of physical and functional characteristics of a facility.

(Smith & Edgar, 2008)

Multidisciplinary collaboration is essential in developing high performance buildings. With the development of BIM (Building Information Modeling Software), professionals are able to simultaneously apply their unique specialties, cross reference each other's work, and view the same project through different lenses: architectural, structural, mechanical, or electrical. (Novitski,2011)

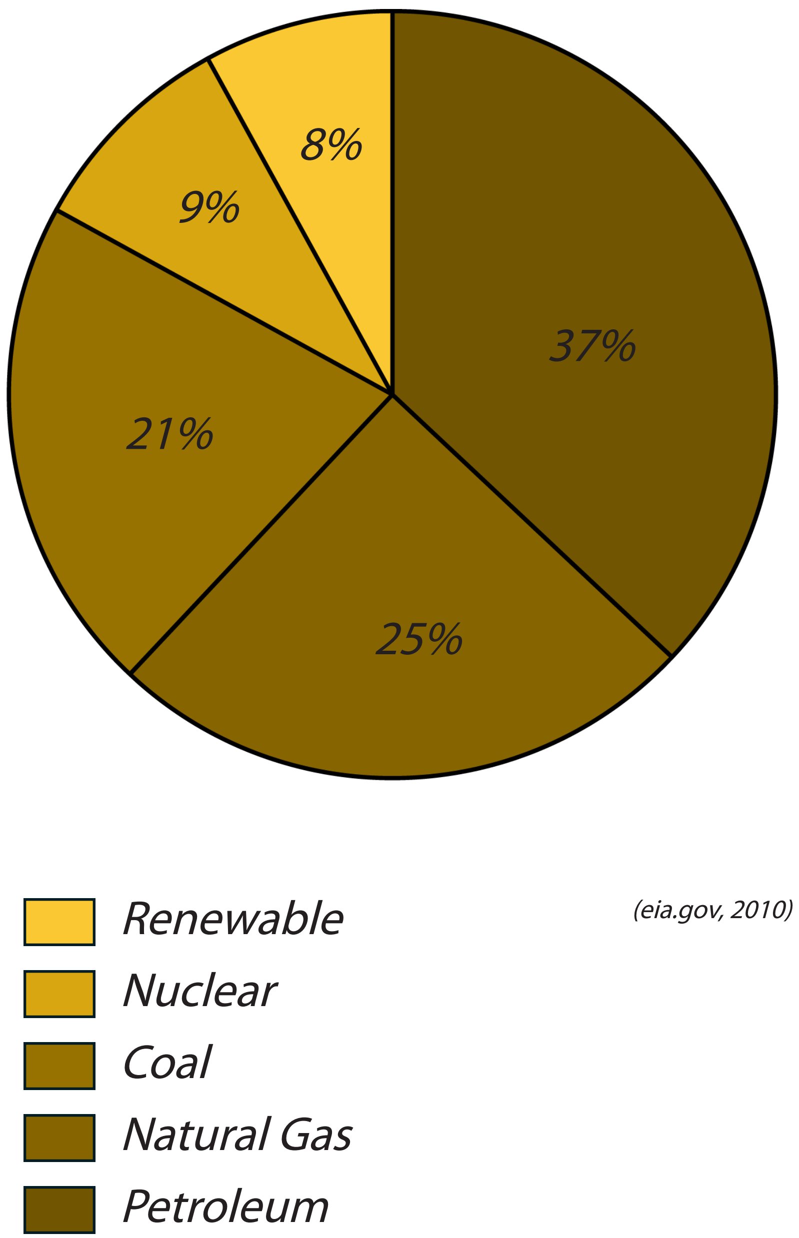
With BIM, it is possible to more accurately depict how a building will function within its context before it is built. Environmental analysis tools, such as Autodesk's Ecotect, Revit Energy Analysis, and Green Building Studio can provide simulations and functionality analysis which can gauge carbon emissions, thermal performance, water usage, solar radiation, shadows, and day-lighting during conceptual stages of design. As the design moves toward construction stages, BIM becomes a tool which architects can use to calculate the number of building components, applications, and materials required for a design, which reduces recalls and waste on the site.

BIM has the potential to change the role of drawings in the construction process, improve architectural productivity, and make it easier to consider and evaluate design alternatives. BIM will also aid in the process of integrating the various design teams' work, further encouraging and demanding an integrated team process (Prowler, Vierra & Winter, 2011).

"Buildings will be built directly from the electronic models that BIM creates, or that architects will no longer create drawings but will instead build buildings inside their computers."

(Prowler, Vierra & Winter, 2011)

U.S. Primary Energy Consumption
2010



(eia.gov, 2010)

OIL

Petroleum can be found in most consumer items such as plastics, and is used to power motor vehicles, heat homes, etc. According to the U.S. Geological Survey, earthquakes and land subsidence have been induced by oil extraction, and spills from rigs and oil tankers have devastated wild-life ecosystems. Before petroleum can be used it must be refined (USGS, 2011). Upon consumption it gives off emissions which have negative impacts on both human and environmental health.

COAL

Of all coal mined, 93% is processed and burned for energy. In the United States, 70% of coal is extracted from the earth through surface mining, which alters the landscape and contaminates natural habitats. The combustion of coal produces 81% of greenhouse gas emissions from electricity, which is said to have a negative effect on the world climate.

NATURAL GAS

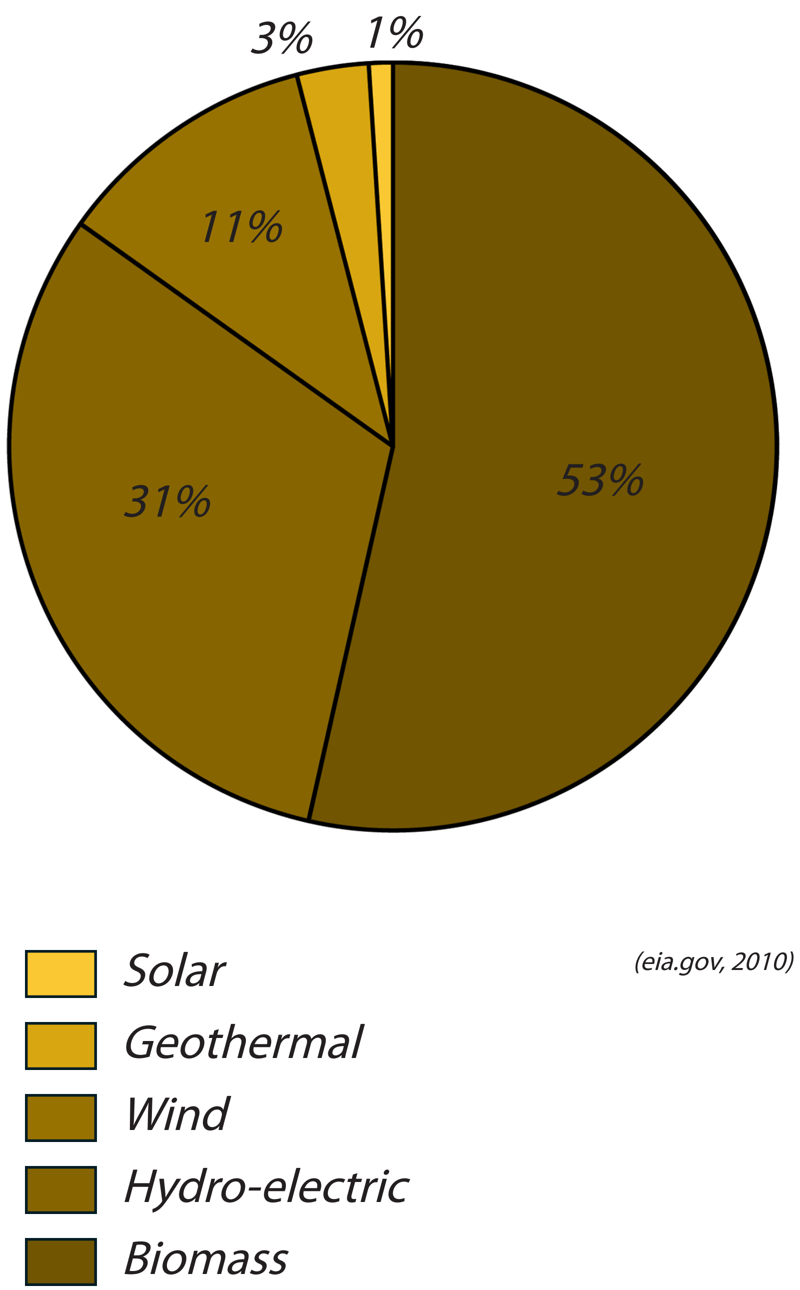
Most natural gas in the United States is produced in the U.S. and Canada. Geologists use seismic surveys to determine where to drill for natural gas deposits. In the United States, 34% of natural gas is used for electric power, 32% for industrial use, and 18% for residential (Gruenspecht, 2012)Extensive land development is required to bury pipes for the gas to travel to the customer, which has caused alterations to the environment.

URANIUM *(Nuclear)*

Nuclear power generates 20% of the electricity used in the U.S. and is solely used for that purpose, though according to the Energy Information Administration, 92% of the uranium used is imported from foreign countries (Yergin 2012). Uranium is an abundant metal that is mined and refined before use in a nuclear reactor to generate electricity. The resulting exhaust is steam and radioactive waste; the waste is contained in geological sites where it will decay over time. Accidents such as Chernobyl and Fukushima have made countries shy away from nuclear energy and to instead seek renewables and other alternatives. (Yergin 2012)

U.S. Renewable Energy Consumption

2010



BIOMASS

Organic materials and waste such as wood, crops, and manure are stored as methane gas, ethanol, or biodiesels and later consumed for heat energy. Crops for biofeuls, if not monitored closely, will continue to put an economic strain on the national food supply and cost.

HYDRO-ELECTRIC

Using a hydroelectric dam is the most typical method for generating electricity: however, there is now technology which allows electric generation through waves and tides. Dams can create negative environmental impacts by straining wildlife ecosystems.

GEOTHERMAL

Geothermal systems require pumps to move either air or liquid into the earth where heat is transferred and then brought back to the surface where the heat is dispersed or transfered. The pumps require a significant amount of electric energy to operate, and if equipped with a solar electric system, it can avoid some dependency on primary resources.

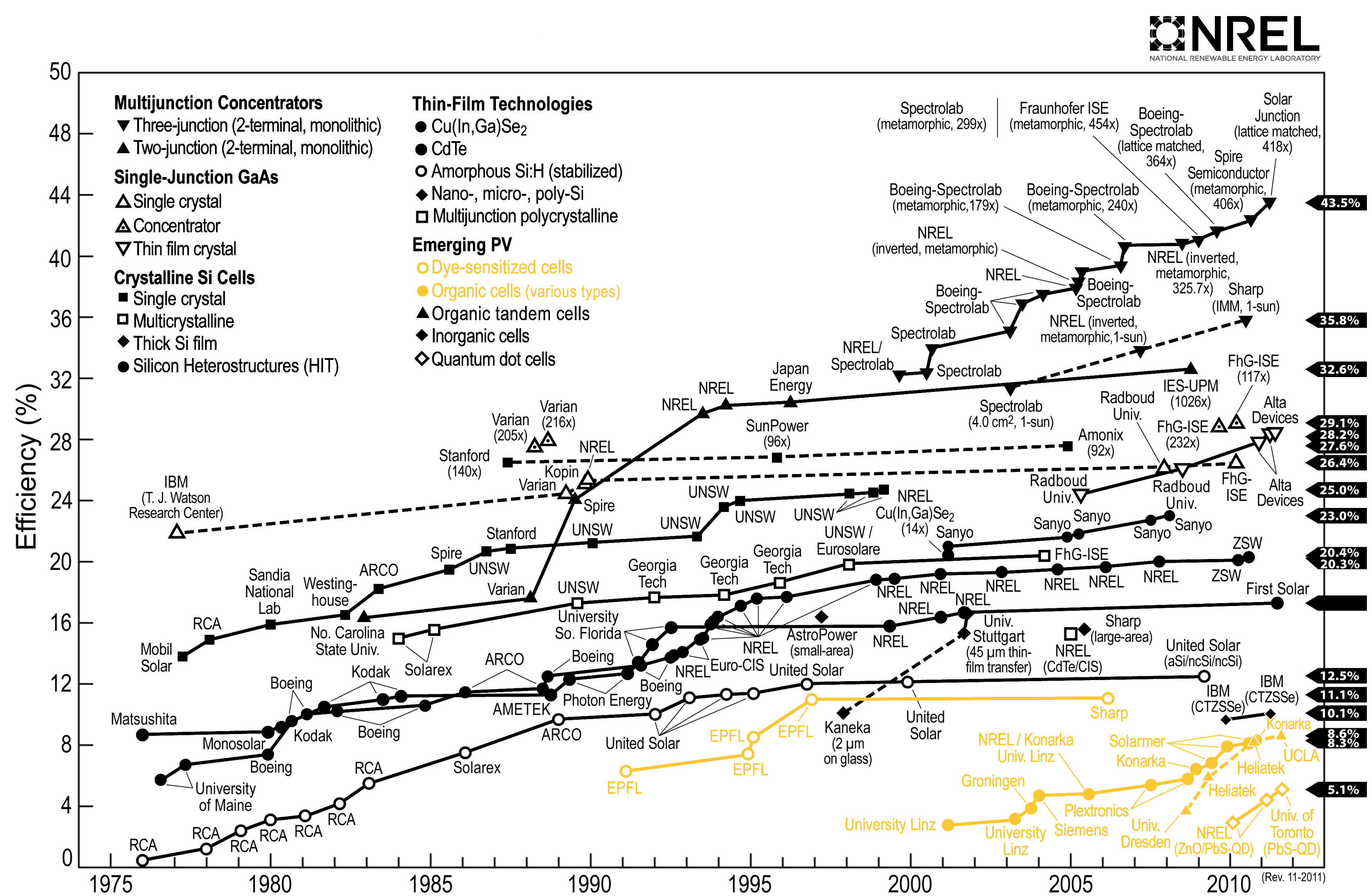
WIND

The earth's geography and continually changing temperature create the wind that turns either horizontal or vertical wind turbines. These machines contain a significant amount of embodied energy in terms of materials and construction. However, the payback over using conventional energy is tremendous. Some types of wind turbines and wind projects are known to negatively impact bird and bat populations.

SOLAR

The sun's rays can be harnessed as either heat energy with solar heat collectors, or electricity with photovoltaic modules. Most collectors and modules carry a significant amount of embodied energy and require toxic materials to manufacture or operate and should be contained so as not to harm natural environments.

Renewable energy, such as biomass, hydropower, geothermal, wind, and solar energy use resources which are naturally available or can be replenished in a relatively short period of time. In the past, these technologies have been more expensive to operate and manufacture compared to the combustion of fossil fuels, however according to the data compiled by NREL (National Renewable Energy Laboratory), technological advances over the past ten years have boosted efficiency and lowered initial costs. Of course like many renewable sources, they are limited by the fact that they are not always available (eia.gov), and the manufacturing process, like the construction of an off site power plant or pipes to transport natural gas, may contain a significant amount of embodied energy. Technological strides are being taken to dampen, or even eliminate, the negative impacts of renewable energy technology.



DYE-SENSITIZED SOLAR CELLS (DSSC)

Dye Sensitized Solar Cells (DSSC) are the latest in photovoltaic technology, and unlike their silicon-based counterparts, they are composed of dyes and polymers, making them less expensive, require less energy to manufacture, and are more durable. The drawback is that their expected life cycle is 10 years, and efficiency at converting the sun's energy is at 11% which is half of a silicon based module, requiring twice the surface are to produce the same amount of energy.

SOLAR THERMAL COLLECTORS

Developed by Hottel and Whillier in the 1950's, heat collectors capture the sun's heat and then transfer it via air or liquid to livable space, water heaters, or heat storage. Flat-plate heat collectors are incredibly durable and if maintained have a relatively long life cycle. Evacuated tubes on the other hand, are the latest in thermal heat collection and are tremendously more efficient; however, they are fragile and are more easily damaged in transport and violent weather.

ARTIFICIAL LEAF

Research done by MIT professor Daniel Nocera has lead to a potentially low-tech method for storing the suns energy. The Artificial Leaf is able to split hydrogen and oxygen by using a silicon solar cell and catalytic materials to perform a chemical reaction when sunlight reaches the solar cell. The concept is that sunlight could be stored as hydrogen for later use to cleanly power everything from appliances, personal vehicles, and possibly buildings. However, a method for exctracting the hydrogen once it has split is still under development.

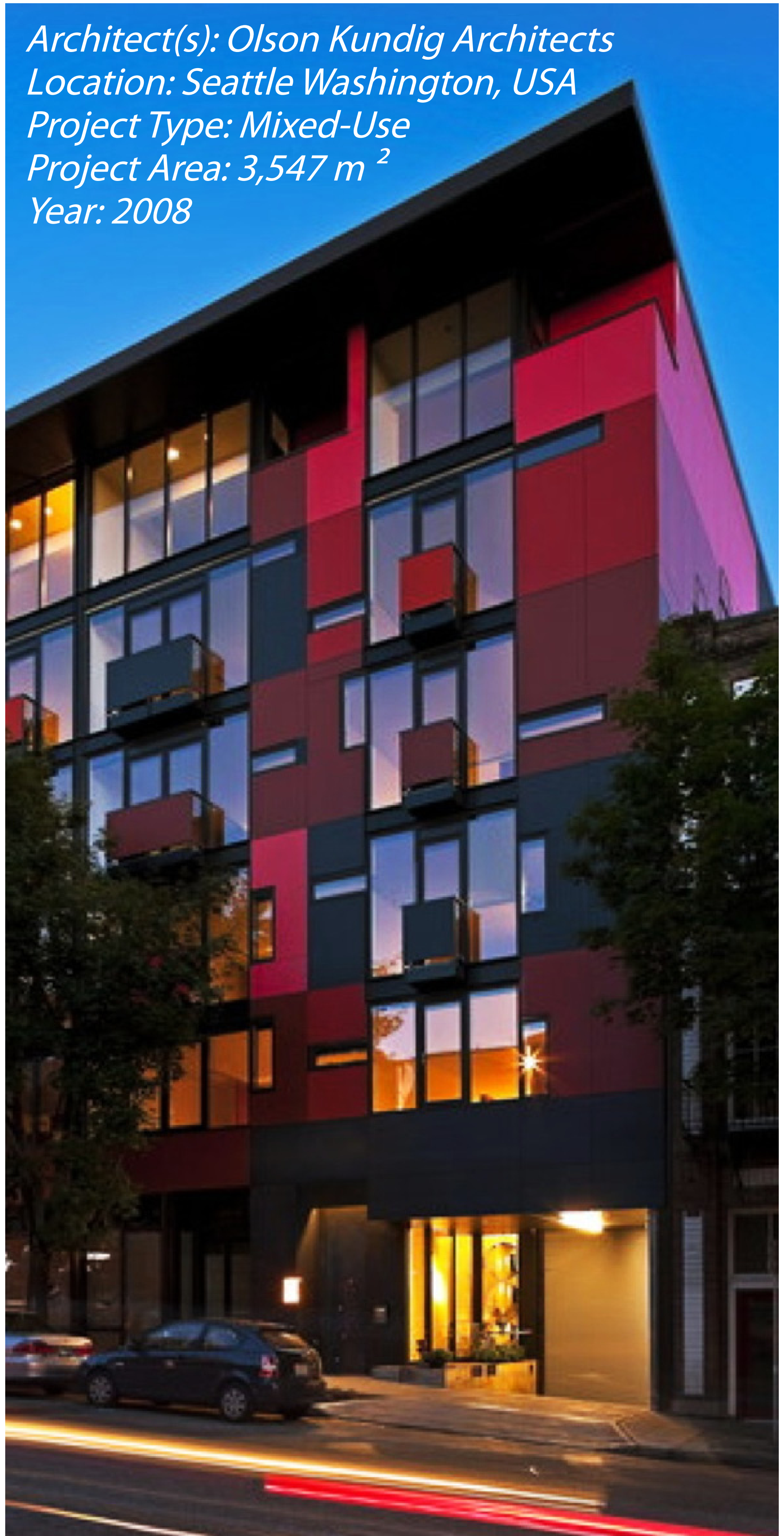
CASE STUDIES | SUMMARY

Every building depicted in this study is a mixed-use typology, containing varying spaces and functions such as restaurants, retail, and residential. Buildings which are diversified in function can utilize land more efficiently when it is scarce and can meet the needs of future uses.

Despite the varying cities and climates in which these buildings reside, this study will reveal that each of them strives to achieve high standards of usability, performance, and innovation by exploring passive and active strategies in early stages of design and carefully selecting materials and construction methods to keep initial and life cycle costs down.

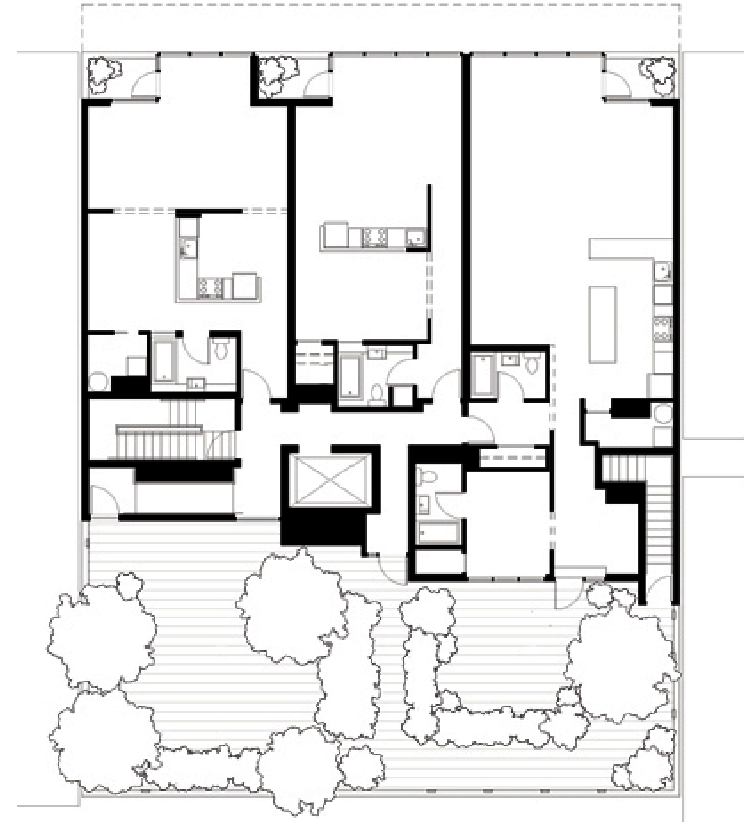
Despite the careful attention to detail and functionality of these buildings, what sets each of these LEED certified buildings apart from others is their integration with the site and immediate accessibility to public transportation, illustrating that energy efficiency goes beyond a buildings property line.

Architect(s): Olson Kundig Architects
Location: Seattle Washington, USA
Project Type: Mixed-Use
Project Area: 3,547 m²
Year: 2008



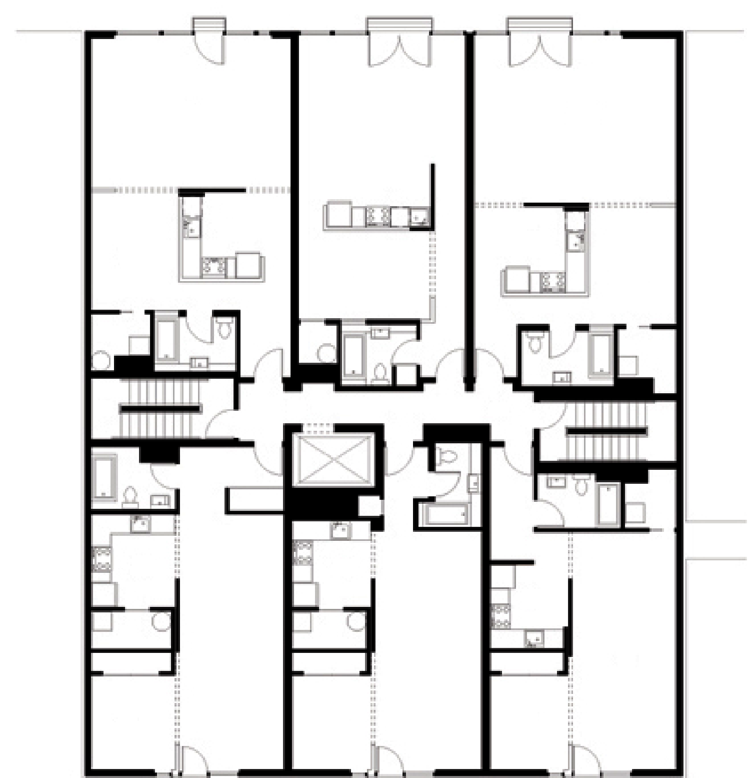
(Zera, 2010)

1111 E. PIKE

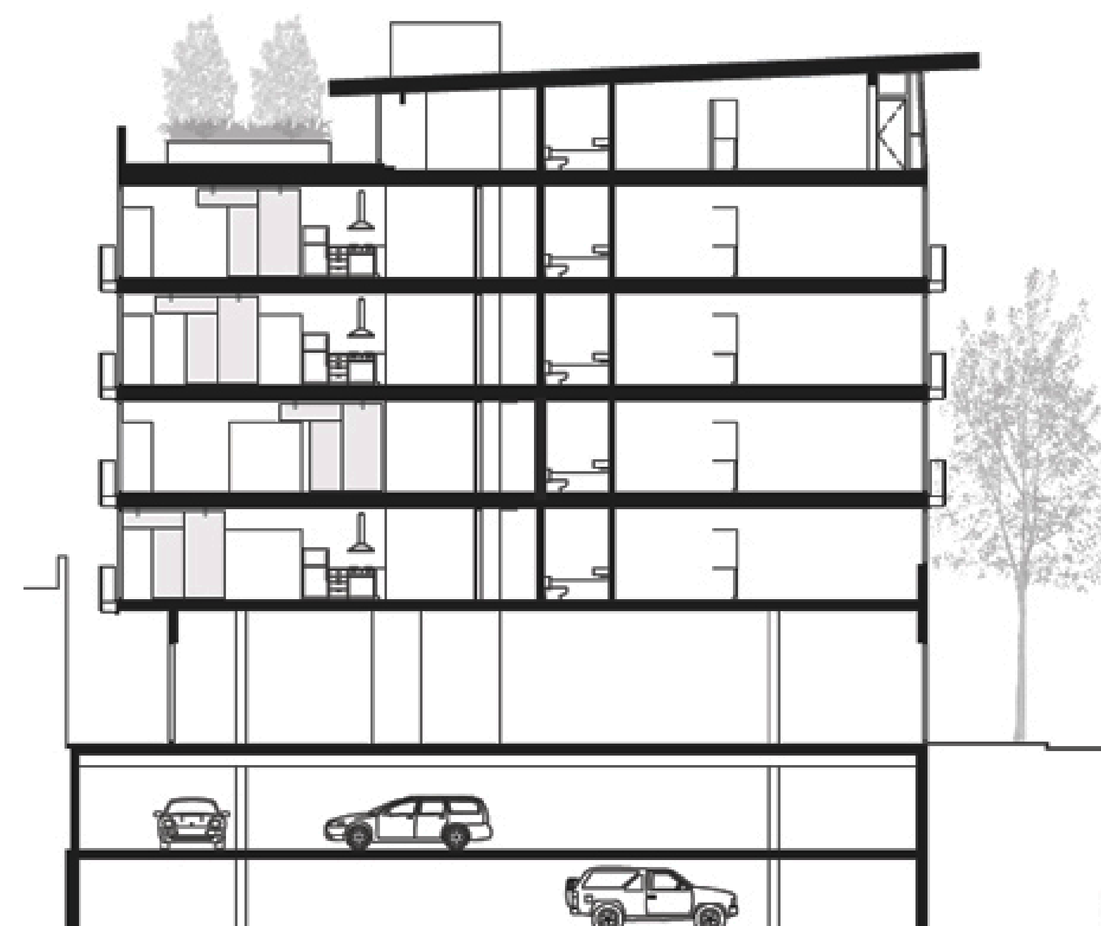


Upper Level Plan

North Elevation



Mid Level Plan



Section

PROJECT DESCRIPTION

OVERVIEW
This 3,547 m² urban in-fill project in Seattle, Washington, occupies a 550 m² lot and features ground-level retail space, five levels totaling 33 condominiums, two underground parking levels, and a roof-top garden.

STRUCTURAL SYSTEM
The first floor is a Type 1 cast-in-place concrete up to the second floor. The second floor uses a post tensioned concrete slab which all other floors are built using Type V light wood framing to keep costs down to $16/m².

ENVELOPE
Drawing from the Pike/Pine Corridor, also known as auto row, historical background in the auto industry, the color palette of the painted fiber-cement panels was inspired by vintage 1920's automobiles. The retail space features an anodized aluminum store front glazing system. All residential windows have aluminum frames. The roof is a torch down assembly.

SPACE
The condominiums in particular feature open plan layouts with modular walls so residents can alter their living space. There are roughly three meter floor to ceiling windows for natural day lighting. The top level has access to a roof top garden. All circulation and mechanical spaces are at the center of the building.

NOTABLES

Winner of AIA National Housing Award 2011

The project meets LEED requirements for:
Development Density
Site Selection
Alternate Transportation
Storm-Water Management.

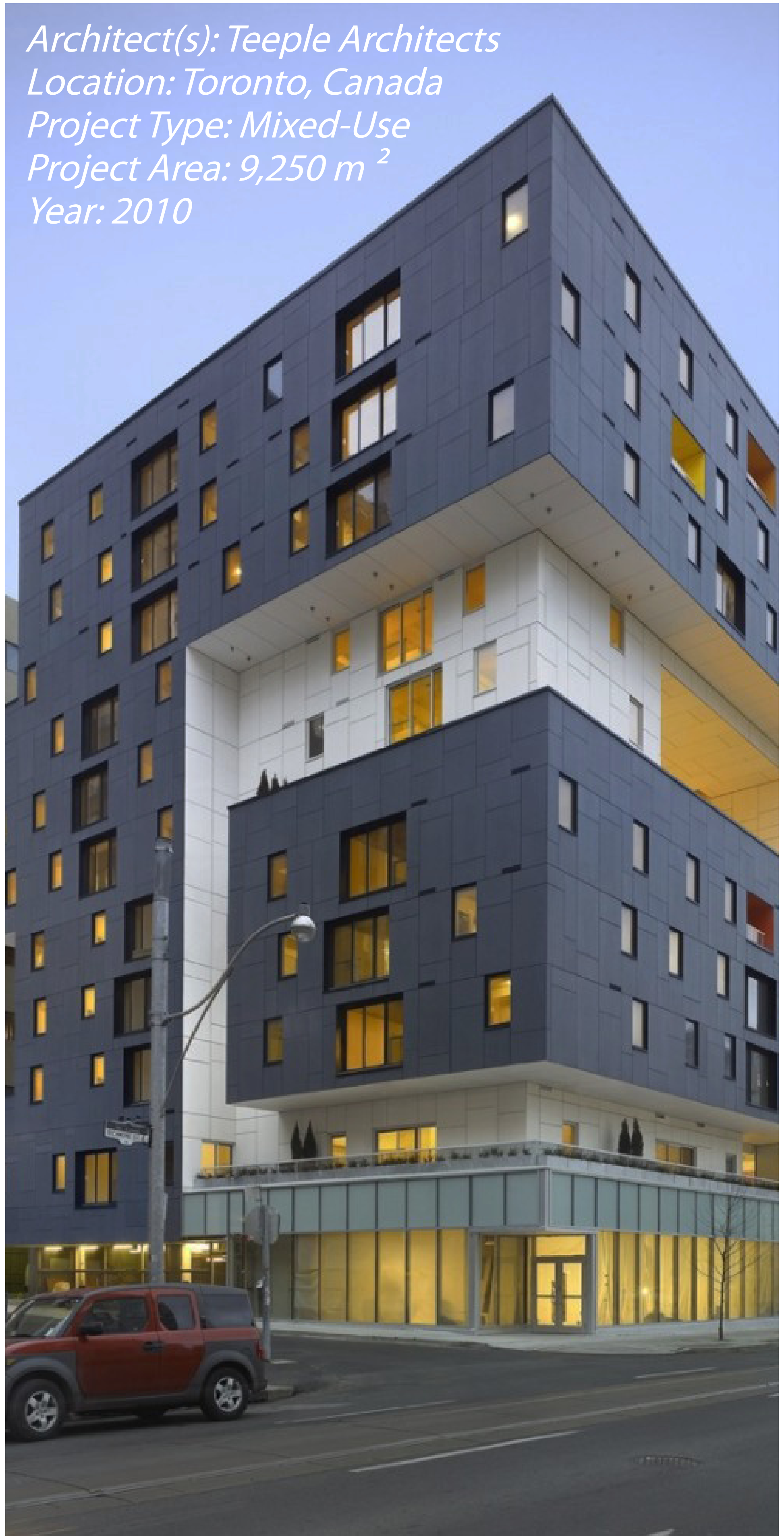
1111 E. PIKE

Upper Space & Circulation

Mass & Void

Lower Space & Circulation

Vertical Circulation & Common Utilities

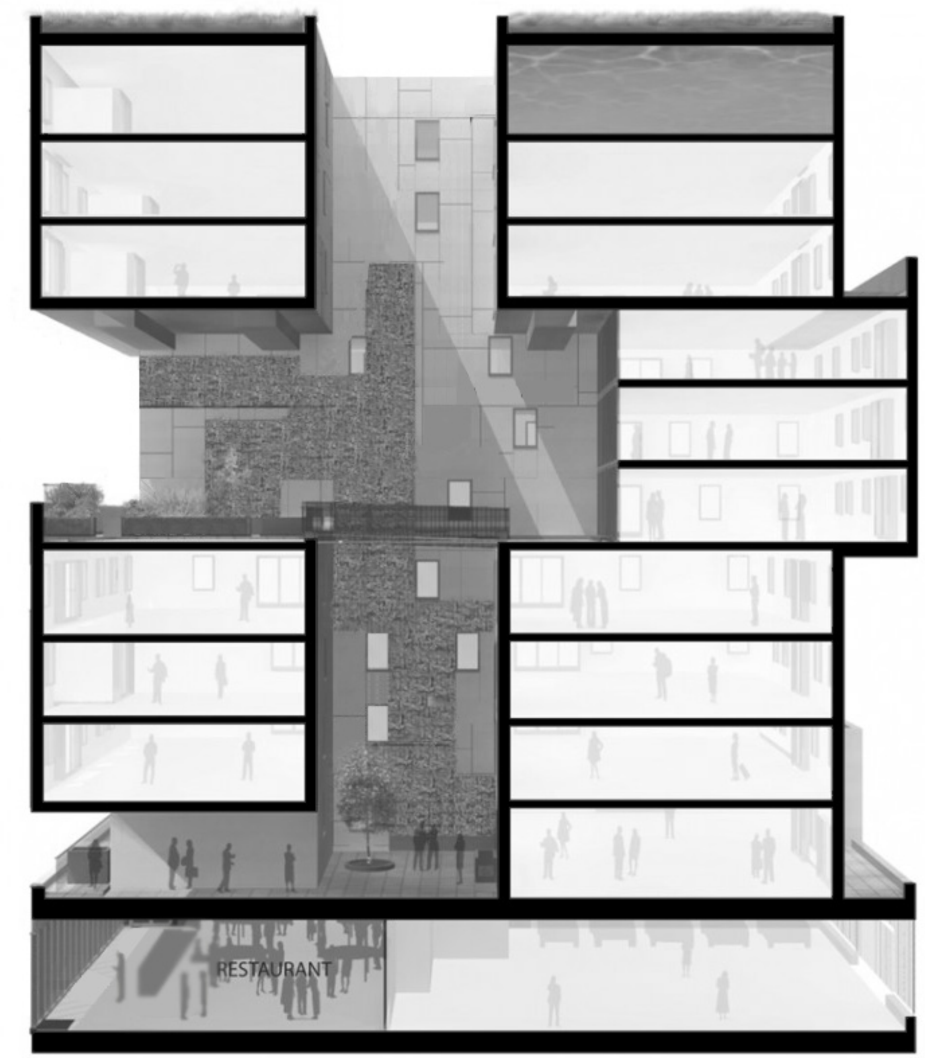


(Gil, 2010)

60 RICHMOND HOUSING CO-OP

Upper Level Plan

Lower Level Plan



Section Perspective

PROJECT DESCRIPTION

OVERVIEW

This 9250 m² urban in-fill project in Toronto, Canada, features a ground-level kitchen to serve the public, five levels totaling 85 apartment units, integrated parking and bicycle storage, and a mid-level community garden.

STRUCTURAL SYSTEM

The entire building is held up by a robust concrete superstructure to handle heavy loads from the green roof and elevated cistern.

ENVELOPE

A low-maintenance building was desired by the client, so a system which allows water to flow behind the skin of the building, known as an insulated rain screen, was selected. A ratio of 40% high-performance glazing and 60% solid exterior was determined to maximize performance. The building also features a sophisticated mechanical and heat recover system. The green roof, which will lower the heat island affect, required a heavy built up roof system.

SPACE

To encourage less energy-intensive transportation, there is limited parking, in-door storage for bicycles, and the building is in close proximity to public transportation. A full-height courtyard occupies the central core of the building, bringing light and air inside and creating a stack effect for ventilation. The adjacent sixth floor roof garden is tended by residents for the production of vegetables for the restaurant, and compost from the kitchen is used to fertilize the growing soil. This raised courtyard also provides space where families can gather.

NOTABLES

On track to acquire LEED Gold Certification.

60 RICHMOND HOUSING CO-OP

Upper Space & Circulation

Lower Space & Circulation

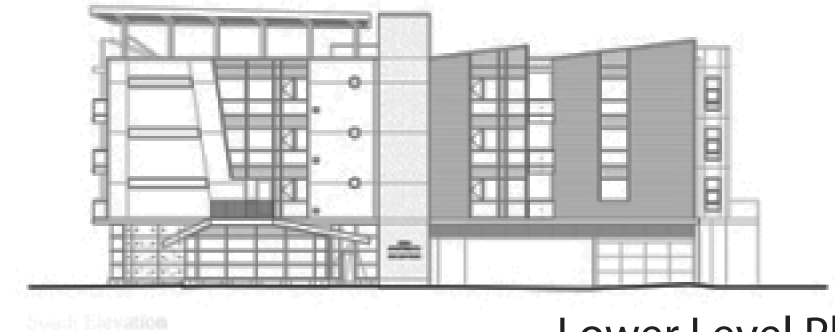
Mass & Void

GISH APARTMENTS

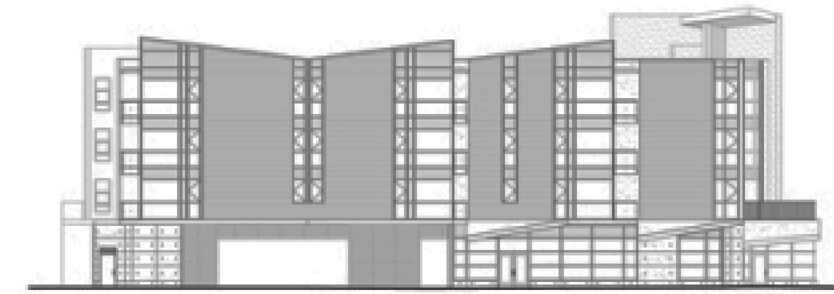
Architect(s): Jerome King Architecture
Location: San Jose, California
Project Type: Spacial Needs, Mixed-Use
Project Area: 6,990 m^2
Year: 2007

(Oberdorfer, 2010)

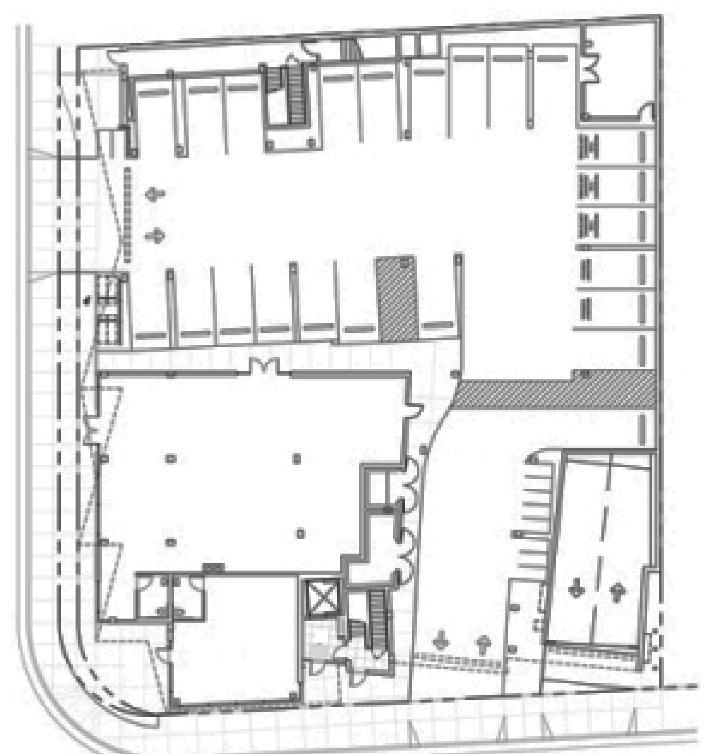
Upper Level Plan



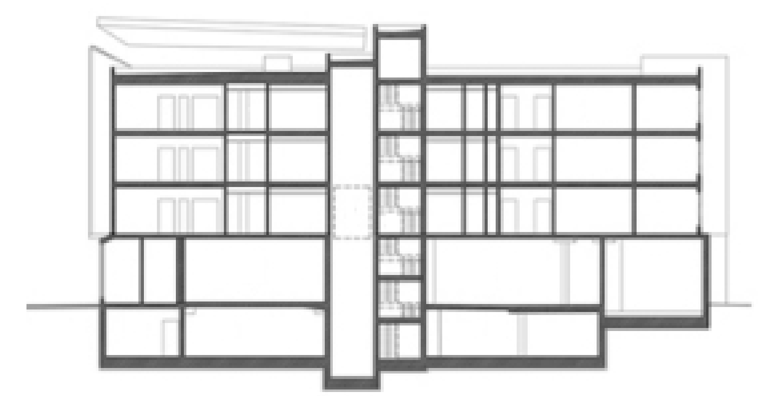
Lower Level Plan



Lower Level Plan



Lower Level Plan



Section

PROJECT DESCRIPTION

OVERVIEW

This 6,990 m² urban in-fill project in San Jose, CA, occupies a 1,685 m² lot and features a ground-level retail convenience store & salon three levels, totaling 35 units of affordable housing, two underground parking levels, and a roof-top solar array which produces an estimated 42,534 kWh per year.

STRUCTURAL SYSTEM

Pre-cut lumber packages, built-up headers, and micro-lam framing materials were used to keep construction costs down.

ENVELOPE

The exterior of the building is equiped with thermal massing, high performance insulation in 2x6 exterior walls, and double-glazed windows.

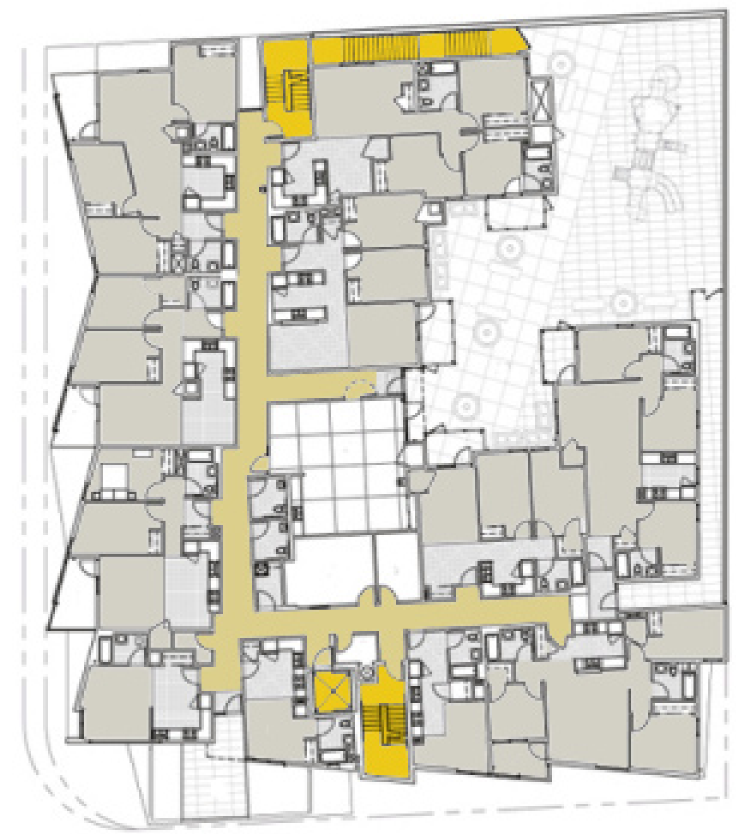
SPACE

The saw tooth form was designed to block traffic noise from the adjacent street and transit station, but allow southern light to flood the interior spaces. A mixture of lenoleum floors, non-toxic carpet tiles, low VOC paints and sealants were used specifically for 13 of the 35 living units for disabled persons . The thermal performance is maitained by heavy insulated walls, a reflective roof, and high-efficiency heating and hot water systems.

NOTABLES

- LEED for Homes
- LEED for New Construction Gold Certification.
- AIA/COTE Top Ten Green Projects in 2009
- AIA Santa Clara Valley Chapter in 2008: Honor Award
- AIA EB in 2008: Citation for Excellence in Architectural Design

GISH APARTMENTS

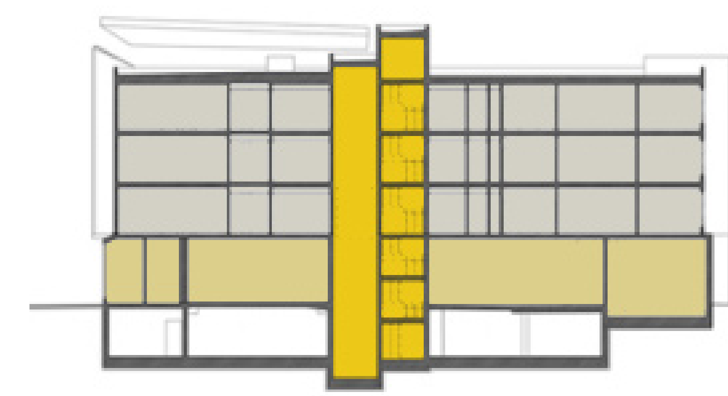


Upper Level Plan

Mass & Void

Mass & Void

Lower Level Plan



Public & Private

From its beginning as a natural assembly for rail and river traffic, Saint Paul's form and growth have been tied to transportation (City of St Paul, 2006-2011). Before becoming a city, St. Paul began as a trading center and stopping point for those seeking to settle in the west in the mid 1800's. The Mississippi River and surrounding St. Peters Stone landforms determined the site for steam boats to dock and later the street grid, which now runs perpendicular to the Mississippi river. When Minnesota became a state in 1858, the city became known as "The City of Saint Paul, State of Minnesota" (City of St Paul, 2006-2011). At this time, the city of St. Paul had grown exponentially from a population of 900 to 10,000.

Up to this point in time, trade and transportation was dominant along the riverways, and by 1860, the population grew to 20,000 with all people arriving by steamboat. It wasn't until 1862 that the locomotive became a prominent mode of transportation, connecting surrounding towns in Minnesota. The Saint Paul and Pacific Railroad was the beginning of a vast network of rails that would dominate transportation in the Upper Midwest.

The current Union Depot train station was completed in 1923 and began to grow into a 9 platform station which served 18 tracks. It was at its peak when train ridership began to decrease with the automobile assembly line turning out more affordable cars, and the operation of public airlines. In 1971 the Union Depot closed because it could not keep up with competing forms of public transportation. The rail lines were then only used as commercial use.

Each year since 2002, residents in the metro area have ranked transportation at the top of the list of regional problems. In 2005, it was reported that rush hour in the Twin Cities lasts for seven and a half hours each day, and the average person wastes $790 and 43 hours per year stuck in traffic (City of St Paul, 2006-2011).In response, the city of St. Paul is seeking to expand and balance its public transportation system. Scheduled for completion in 2014, the new light rail system, or Central Corridor, is planned to extend from Minneapolis to Lower St. Paul. The city is also renovating the Union Depot to meet the demands of a new public AmTrak line, or Red Rock Corridor, which will extend from Hastings, through St. Paul, and into Minneapolis. This line is scheduled to be in operation by 2030.

EXCEL ENERGY

In 1909 Thomas Edison's apprentice, H.M Byllesby, went to Stillwater, MN, and established the publicly traded Consumers Power Co., which in 1916 was renamed to Northern States Power Co. In 1995, NSPE and Wisconsin Energy Corporation (WEC) had planned a merger to form Primergy, but due to the unwillingness of the Energy Regulatory Trade Commissions of Wisconsin and Minnestoa to grant approval, the CEO's of both companies decided to terminate the merger. Both companies sustained substantial losses within the millions, and stocks began to fall.

After the failed Primergy merger, Xcel Energy was formed to combine three formerly independent companies: Northern States Power (Minnesota), Northern States Power (Wisconsin), and New Century Energies. Today Excel Energy is headquartered in Minneapolis and is a major U.S. utility company which supplies electricity and natural gas to 3.3 million electric customers and 1.8 million natural gas customers over 8 states. Xcel Energy uses coal, wind, solar, hyrdo, biomass, and nuclear power to provide electricity to its customers.

DISTRICT ENERGY

In 1979 a public-private partnership was assembled to provide reliable, cost-effective heating service to the northern metropolitan area. Today, District Energy operates the largest hot water district heating system in North America and is considered the most successful in the U.S. in terms of using renewable energy sources and energy conservation (City of St Paul, 2006-2011).

District Energy uses the largest wood fired plant in the U.S. and it heats and cools commercial, residential, and industrial buildings in downtown Saint Paul by using hot water from the adjacent biomass-fueled combined heat and power (CHP) plant. The hot water district heating system is twice as efficient as the previous steam heating system in downtown Saint Paul and heats twice the square footage of building space with the same amount of fuel (City of St Paul, 2006-2011).

OBJECTIVES OF THE THESIS PROJECT

ACADEMIC

This thesis will allow me to compile the knowledge I have acquired through my education and focus it toward my passion for high-performance building design. With our nation facing energy security problems, there has been a demand for more efficient technology integration in buildings. I have come to believe that the concept of integrated design, a collaborative multidisciplinary effort, can turn out high performance buildings and, someday, a ZEB (zero energy building). Through this design thesis, I will have a better understanding of varying perspectives by performing the role of every stakeholder of such a building complex, such as the client, architect, structural engineer, mechanical engineer, etc.

PERSONAL

When I began to deconstruct this nations energy infrastructure, I become alarmed by some prominent deficiencies such as urban sprawl and segregation of building typologies and structures. So much energy is being used to heat separate buildings that could be sharing walls, waiting in rush hour traffic, and transporting primary fuels first before using them when the sun, wind, and water are readily available. Through my education, I have come to believe that walls should be shared and that amenities such as markets and public transportation be within walking distance, which is why my interest has grown toward mixed-use buildings and inner city living.

PROFESSIONAL

Architectural education in particular has encouraged me to acquie a worldly view between varying types of people and how a building impacts the global environment from material extraction to construction, occupancy, and lastly deconstruction. However, when I leave academia I will never stop learning. I understand that this is only the beginning and that I have gone through the rigours of school to essentially "learn how to learn," for when I make it out into the work force as an architectural intern and, someday, as licensed architect. It is my dream to work for a firm that requires some of the same tools and ideologies used to compose this thesis.

SITE ANALYSIS | QUALITATIVE DATA

OVERVIEW

This portion of lower St. Paul remains undeveloped loose end to St. Paul's unified grid and infrastructure. It currently serves as a parking lot that does not have immediate access to the skyway system or other branches of the transportation network. This future transportation node will have the potential to draw customers in for businesses and provide easy access to the public transportation system for residents.

TRANSPORTATION

When the LRT (Light Rail Transit) Central Corridor is operational in two years, and the AmTrack line in twenty years, there will be a greater need for a link between each of these transit hubs. Once renovations are complete, the Union Depot station will once again serve as the public transportation hub for St. Paul.

ENERGY

District Energy will be able to provide more reliable and efficient heating and cooling to constructs on site for a lower energy rate. This will require both supply and return lines in a closed loop system from the Kellog Energy Plant 10 blocks away, eliminating the need for boilers, chillers, and cooling towers. Buildings will instead require heat exchangers for either forced air or underfloor heating systems.

SHADE & SHADOW

Neighboring buildings, such as the Union Depot will shade the site during particular times of day and year. These surrounding forms will determine solar geomoetry, orientation, and gain where and when it is desired.

SITE ANALYSIS | QUALITATIVE DATA CONTINUED

PUBLIC GREEN SPACE

Parks and green space lend uniqueness and identity to a city and its neighborhoods. St. Paul contains 4,123 acres of parks which accounts for 11% of St. Paul's total land area. They provide a strong framework for maintaining and improving every citizen's quality of life, and they form neighborhood focal points for community activity and life (City of St Paul, 2006-2011). Mears Park is only one block away from the proposed site, and is a public space which is maintained as a collaborative effort by local volunteers and citizens of St. Paul.

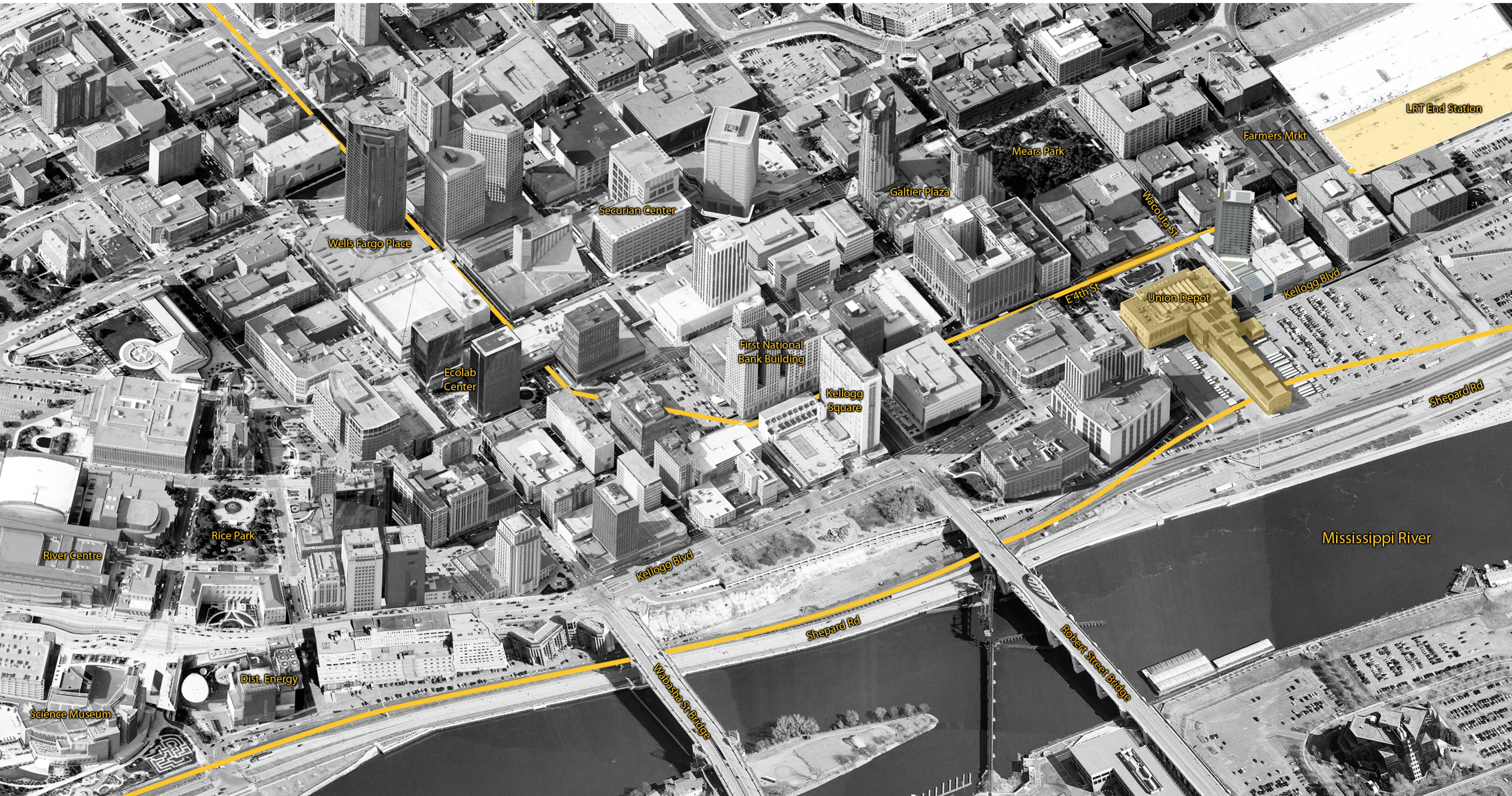
MARKETS

Lower St. Paul has been home to the local farmer's market for over 150 years and is now run by the St. Paul Growers Association. The market, which is only run on weekends, is located one block northwest of the site. It is place where residents from St. Paul and surrounding areas can come to sell and purchase locally grown food. The embodied energy of locally grown food is significantly less than foods which are out of season and/or found in supermarkets because the local foods do not need to travel great distances before they are consumed.

Even though there is a well established farmers market in downtown St. Paul, there is still a great need for corner grocery stores to serve inhabitants during the winter season. Without corner markets, people are forced to become dependent on motor vehicles and supermarkets for their produce. By having numerous markets, cities become more walkable, which reduces traffic and congestion and saves energy that otherwise would be wasted.

OTHER AMENITIES

There are over 175 different restaurants, a variety of shows, events, concerts, and an elevated/sheltered skyway system, to link all the buildings, businesses, shops, residences, and other facilities in St. Paul. During the winter, people can pass between buildings without stepping a foot outside, lowering heat loss durring those months.


LRT End Station
Farmers Mrkt
Mears Park
Galtier Plaza
Securian Center
Wells Fargo Place
Wacouta St
E 4th St
Union Depot
Kellogg Blvd
First National
Bank Building
Ecolab
Center
Kellogg
Square
Shepard Rd
Mississippi River
Rice Park
River Centre
Kellogg Blvd
Shepard Rd
Dist. Energy
Science Museum
Wabasha St Bridge
Robert Street Bridge

Public Rail

UTILITIES: District Energy

Heat Sources:

Main plant, 76 West Kellogg Boulevard
Two coal/gas-fired boilers: 88 MW
Four gas/oil-fired boilers:106 MW
Combined heat and power plant: 65 MW
Regions Hospital plant
Four gas/oil-fired boilers: 25 MW

Piping

Type: Prefabricated steel pipe with polyurethane insulation encased in polyethylene jacket
Diameter: 3/4-inch to 28-inch

Supply Temperature: 190-250 degrees F
Return Temperature:140-160 degrees F
Supply Pressure: 180 psi
Minimum pressure differential:20 psi
Reliability rate: 99.997%

SOIL

99.5% Urban Land

| Average annual precipitation: 27 to 33 inches
| Average annual air temperature: 39 to 46 degrees F
| Frost-free period: 135 to 180 days

Description of Urban Land

| Landform: Moraines
| Down-slope shape: Linear
| Across-slope shape: Linear

.5% Udorthents, Wet substratum

| Average annual precipitation: 27 to 33 inches
| Average annual air temperature: 39 to 46 degrees F
| Frost-free period: 135 to 180 days

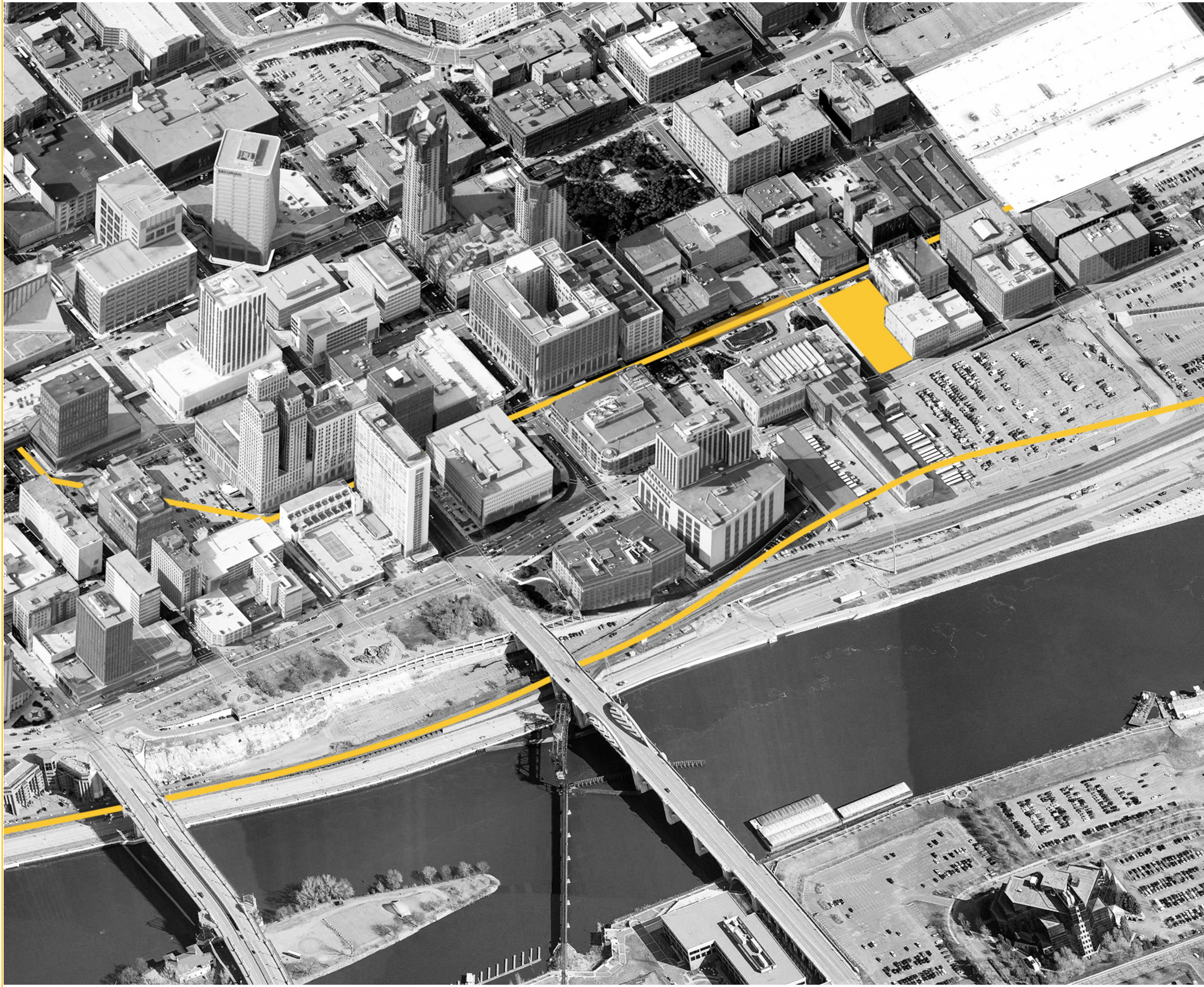
Description of Udorthents, Wet Substratum

| Landform: Moraines
| Down-slope shape: Linear
| Across-slope shape: Linear

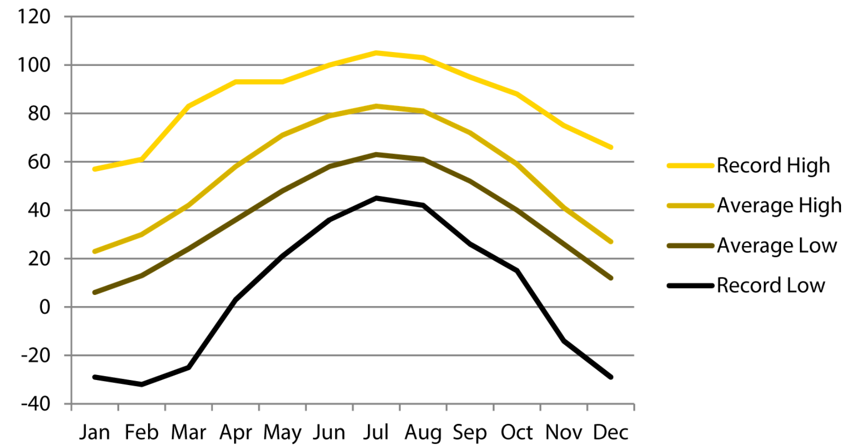
Properties and Qualities

| Slope: 0% to 6%
| Depth to restrictive feature: More than 80 inches
| Depth to water table: More than 80 inches
| Frequency of flooding: None
| Frequency of ponding: None

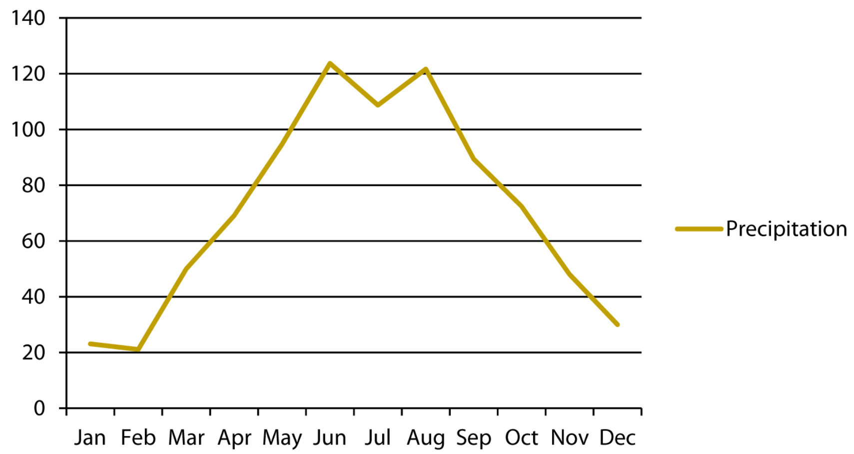
(Web Soil Survey, 2011)



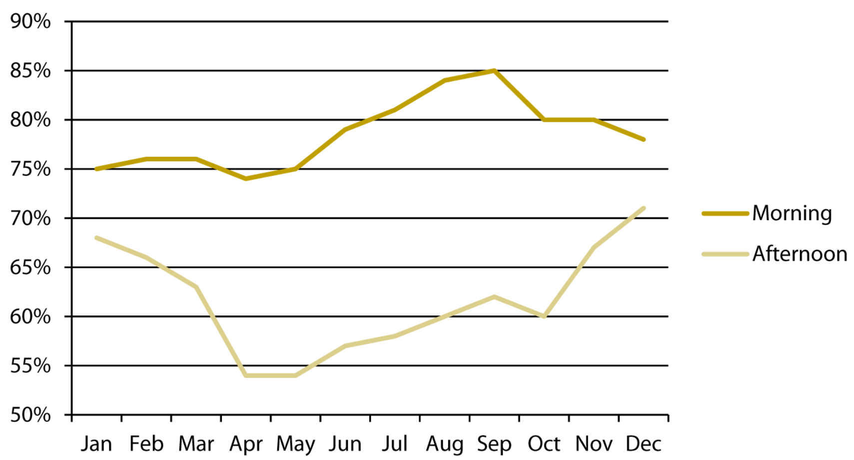
Monthly Temperature °C

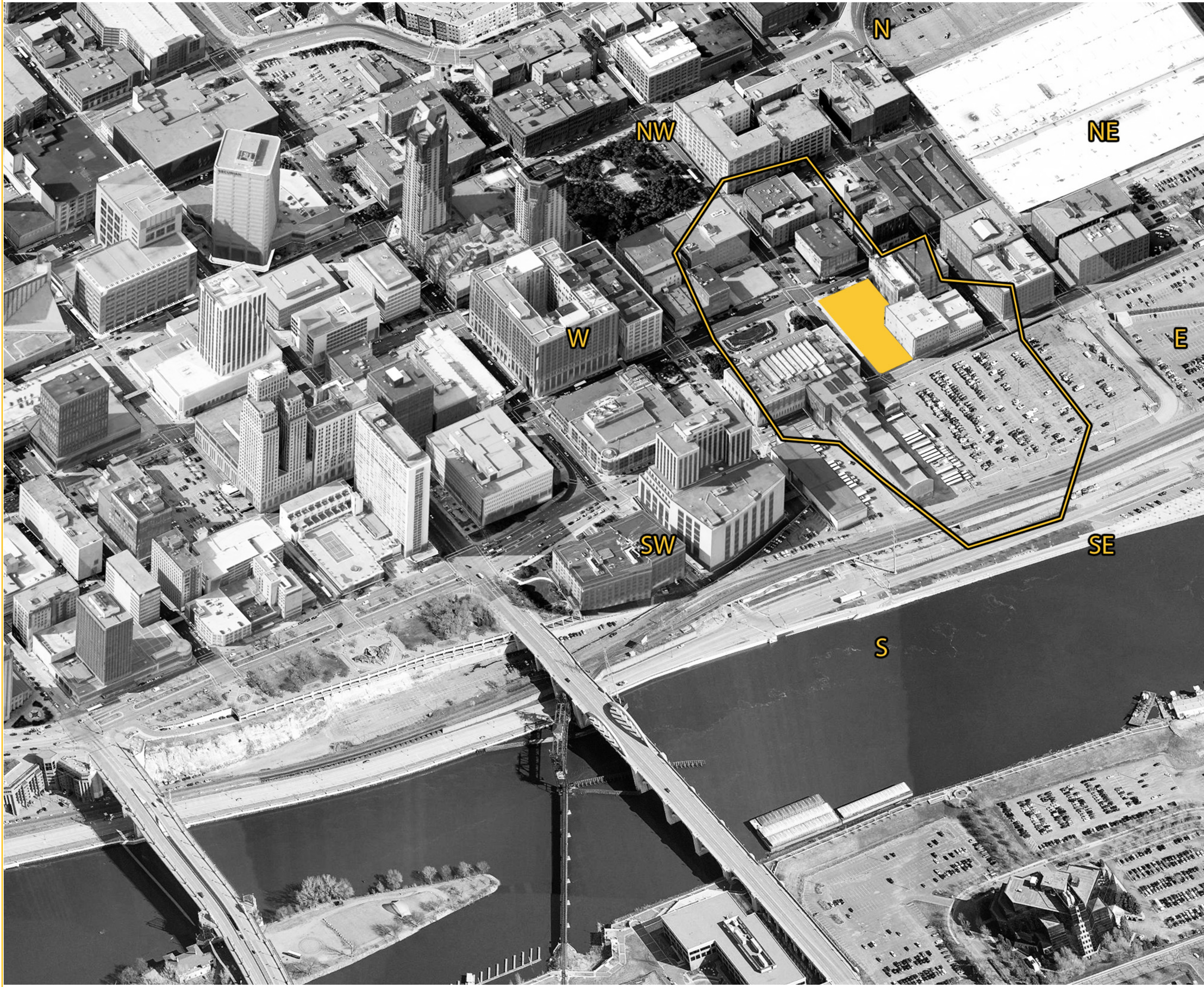


Monthly Precipitation (mm)



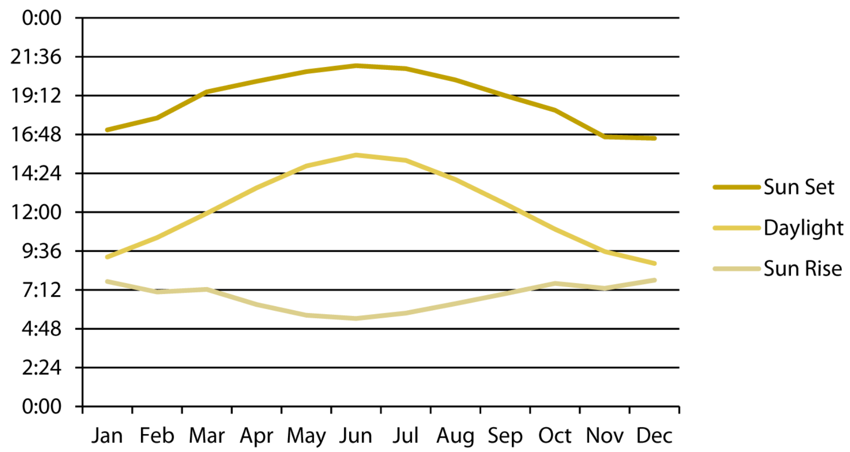
Monthly % Relative Humidity



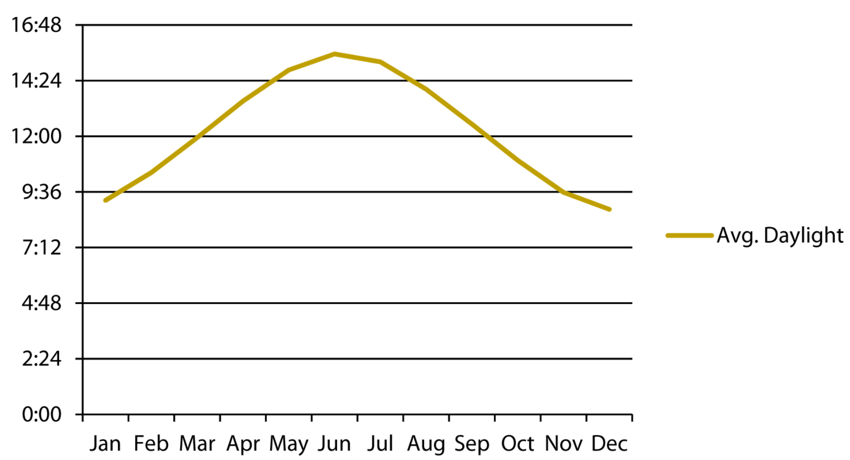


SITE ANALYSIS | DAYLIGHT

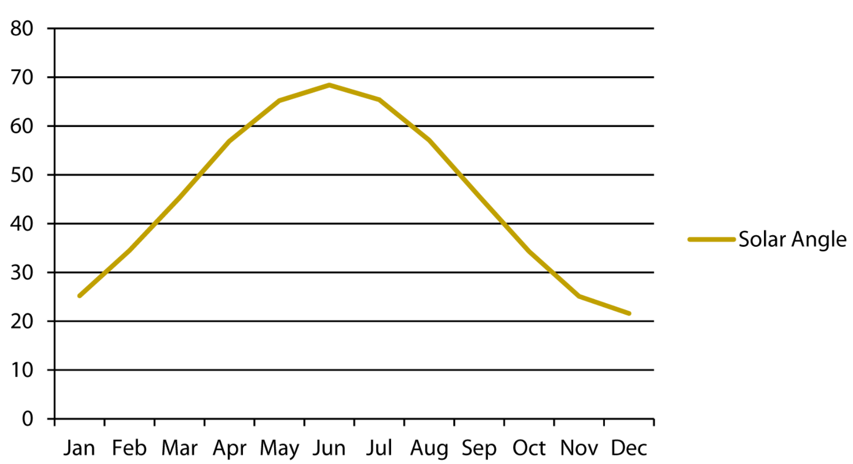
Sunrise & Sunset

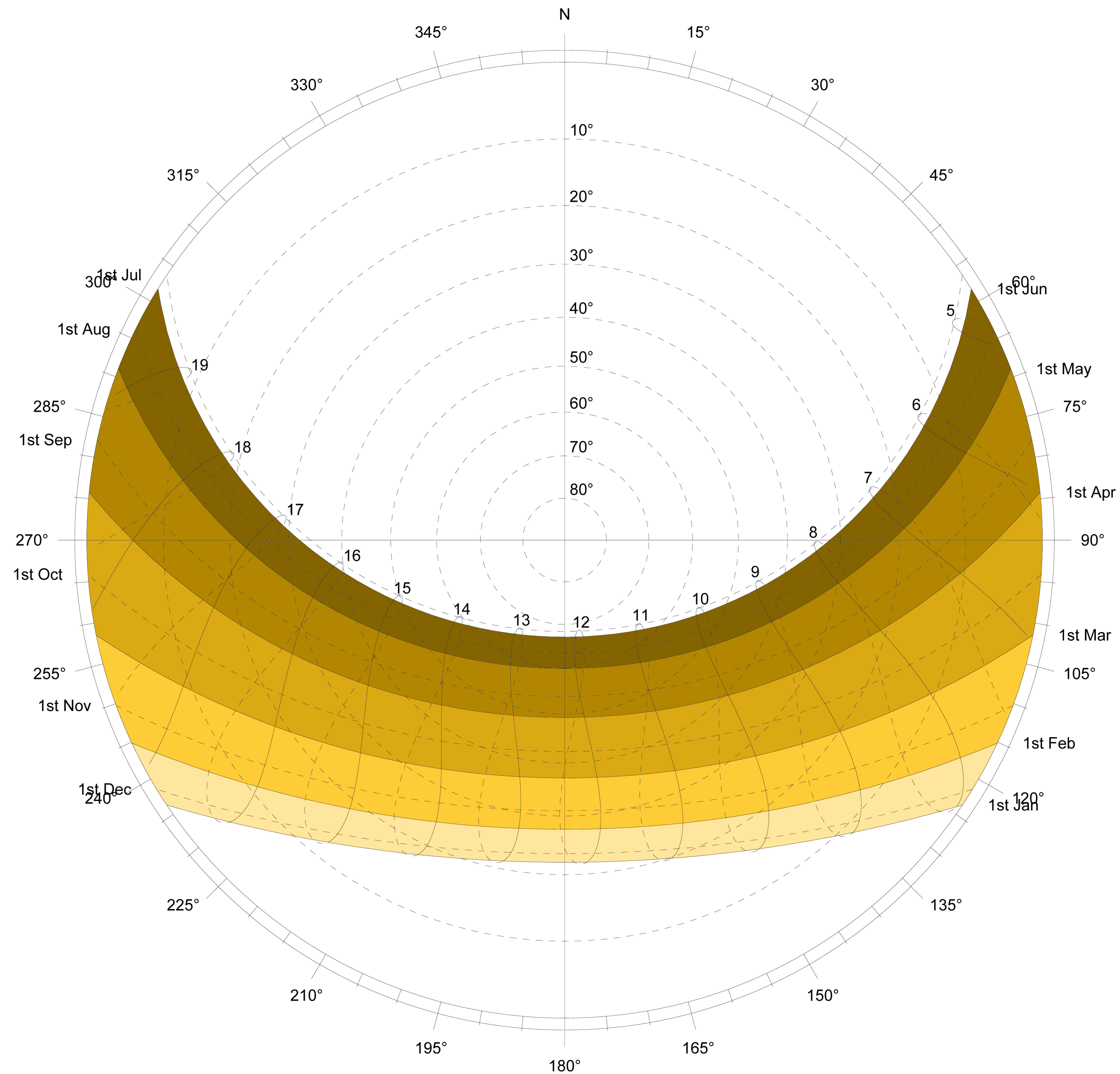


Monthly Daylight Hours

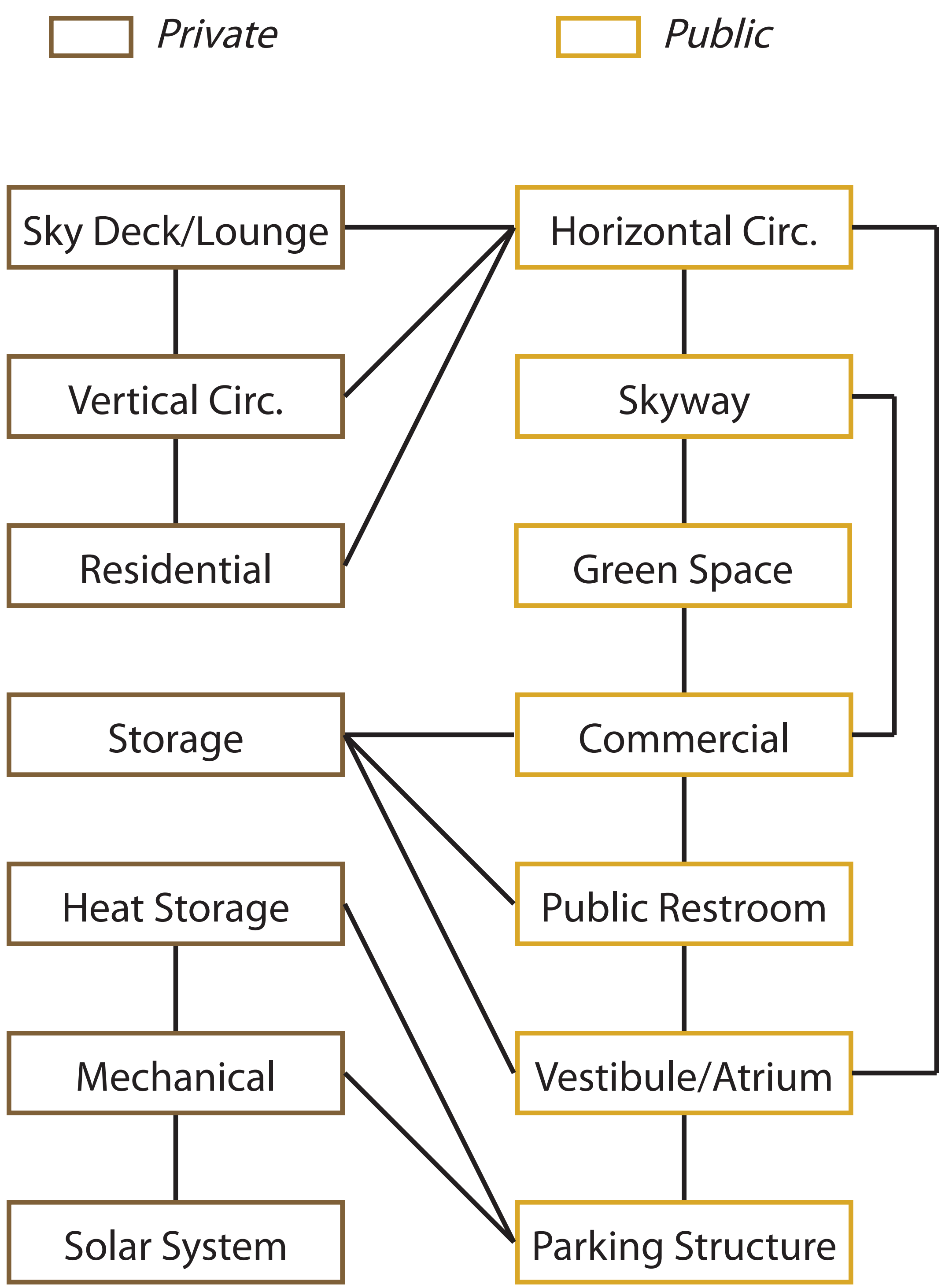


Solar Angle





Interaction Net

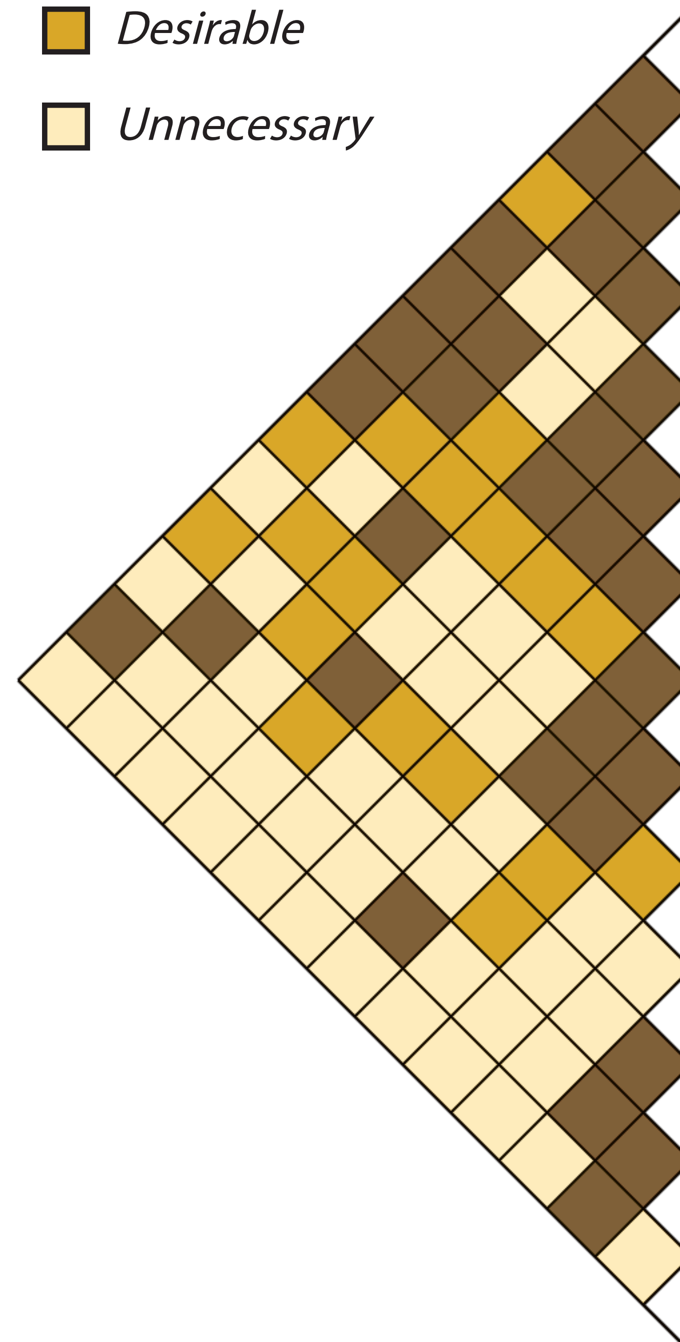


Connection Between Spaces

Strong

Desirable

Unnecessary



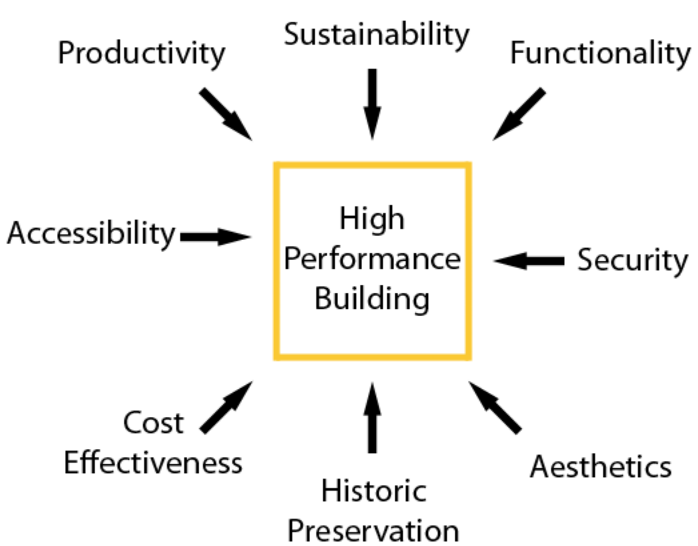
Program		Description
Vestibule/Atrium	*252m²*	A junction which minimizes heat loss from other portions of the building.
Public Restroom	*126m²*	A place that serves visitors and patrons occupying public portions of the building.
Storage	*63 m²*	A nook to store janitorial equipment, supplies, etc.
Commercial	*1,210 m²*	An exchange for retail, services, storage and kitchens.
Green Space	*831 m²*	An outdoor space to look out upon or enjoy when the weather is pleasant.
Skyway	*165 m²*	A bridge which provides access to St. Paul's extensive skyway network.
Horizontal Circ.	*2,261 m²*	A sequence of spaces which provide access to other parts of a particular level.
Vertical Circ.	*909 m²*	A sequence of spaces which provide access to other levels of the building.
Residential	3,840 *m²*	A home for daily rituals and energy conservation.
Sky Deck & Lounge	*1,066 m²*	A meeting place for socializing and events.
Parking Structure	2,520 *m²*	An underground space to park motor vehicles.
Mechanical	*1,350m²*	A place for all the inner workings of the building.
Thermal Storage	*320 m²*	A cache to store energy for when it is needed.
Roof Space	*1,050 m²*	A space for solar arrays and vegetation.
TOTAL	*15,963 m²*	

PART IV | DESIGN DOCUMENTATION

DESIGN EXPRESSION

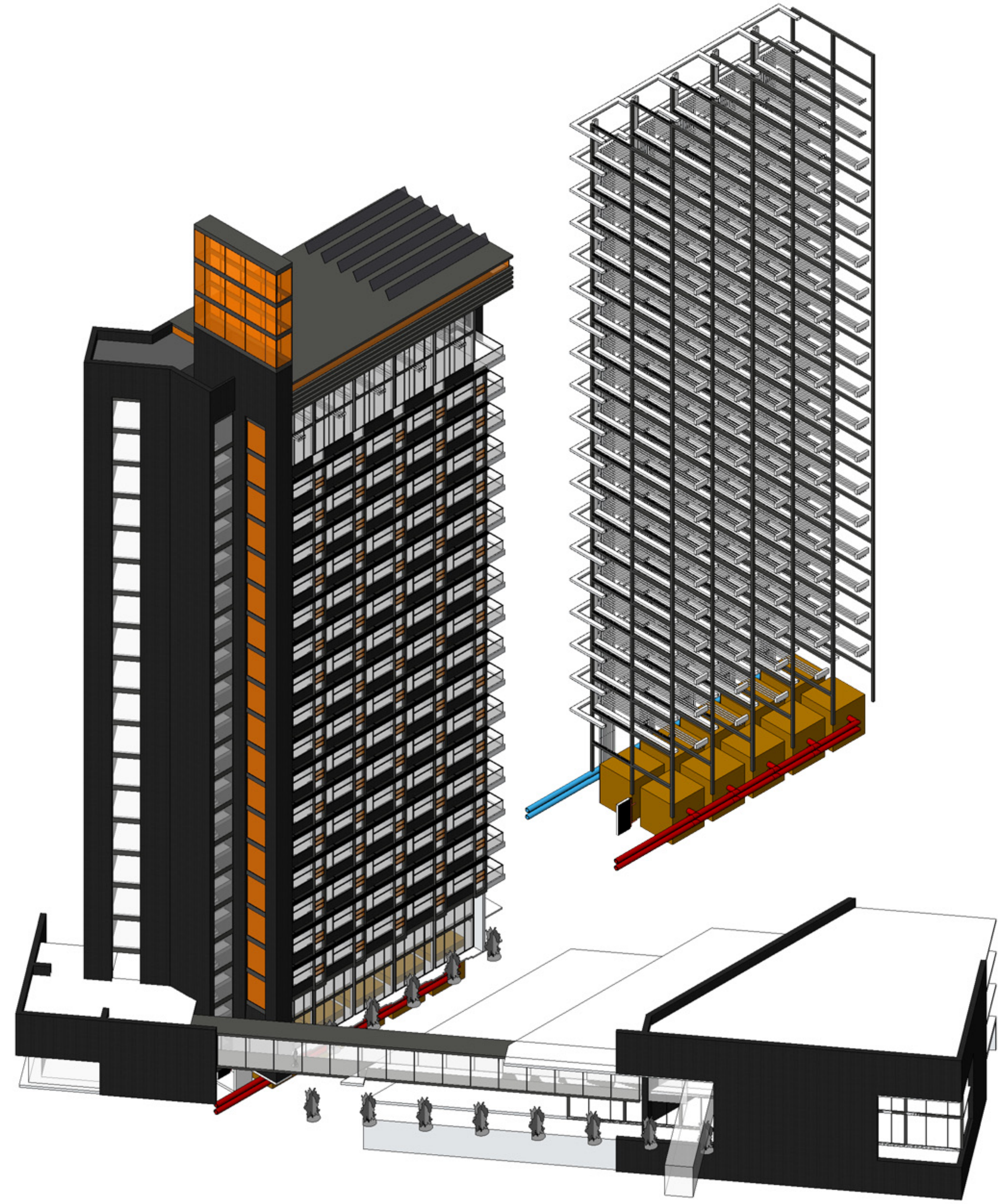
This mixed-use complex aims to achieve high levels of performance not only through extensive systems integration, but by unfolding itself to the public and its inhabitants through an expression of its systems. At the base of the building rests ten thermal storage tanks which store thermal energy provided by District Energy, both hot and cold, during off peak hours to level out the demand curve of energy in St. Paul. The tops of these encased tanks are exposed on the ground level and can be seen from numerous locations on and off site. The dye-sensitized solar modules create a delightful pattern on the south face of the building and provides renewable energy to the residences for appliances and devices which require batteries. Lastly, the solar chimney creates a negative pressure when exposed to the sun which causes air to travel and exhaust at its highest point. This passive system, which towers above, becomes a symbol of conservation for the visitors and citizens of St. Paul, MN.

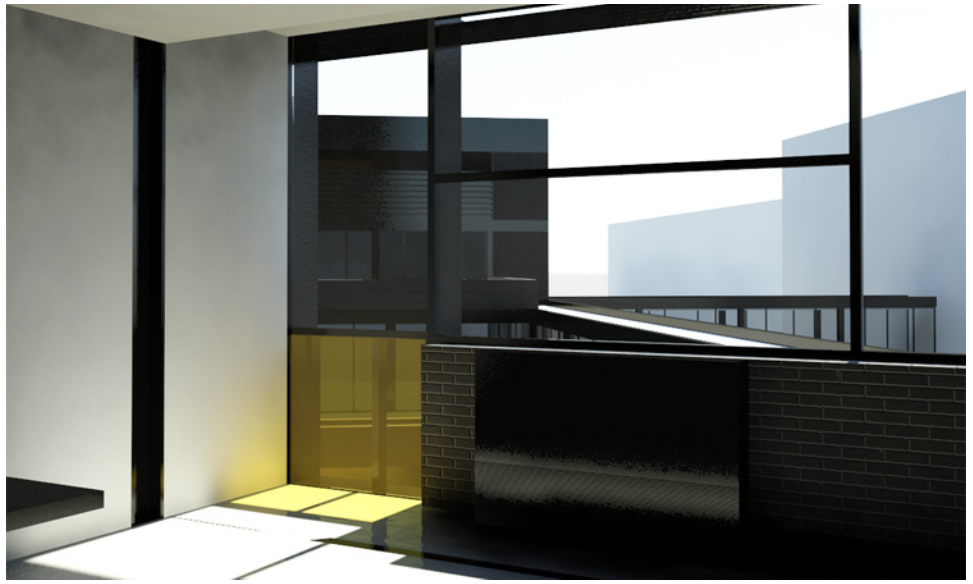
Buildings in today's technologically advanced world are incredibly complex and in many cases require people from varying disciplines to design. Whole building design is about merging varying specialties and good design principles simultaneously during the programming and design phases of a building. This requires multidisciplinary collaboration which emphasizes the development of a design that works as a system of systems from conception to completion. The goal and preferred outcome of such an integrated design process is a high performance building.



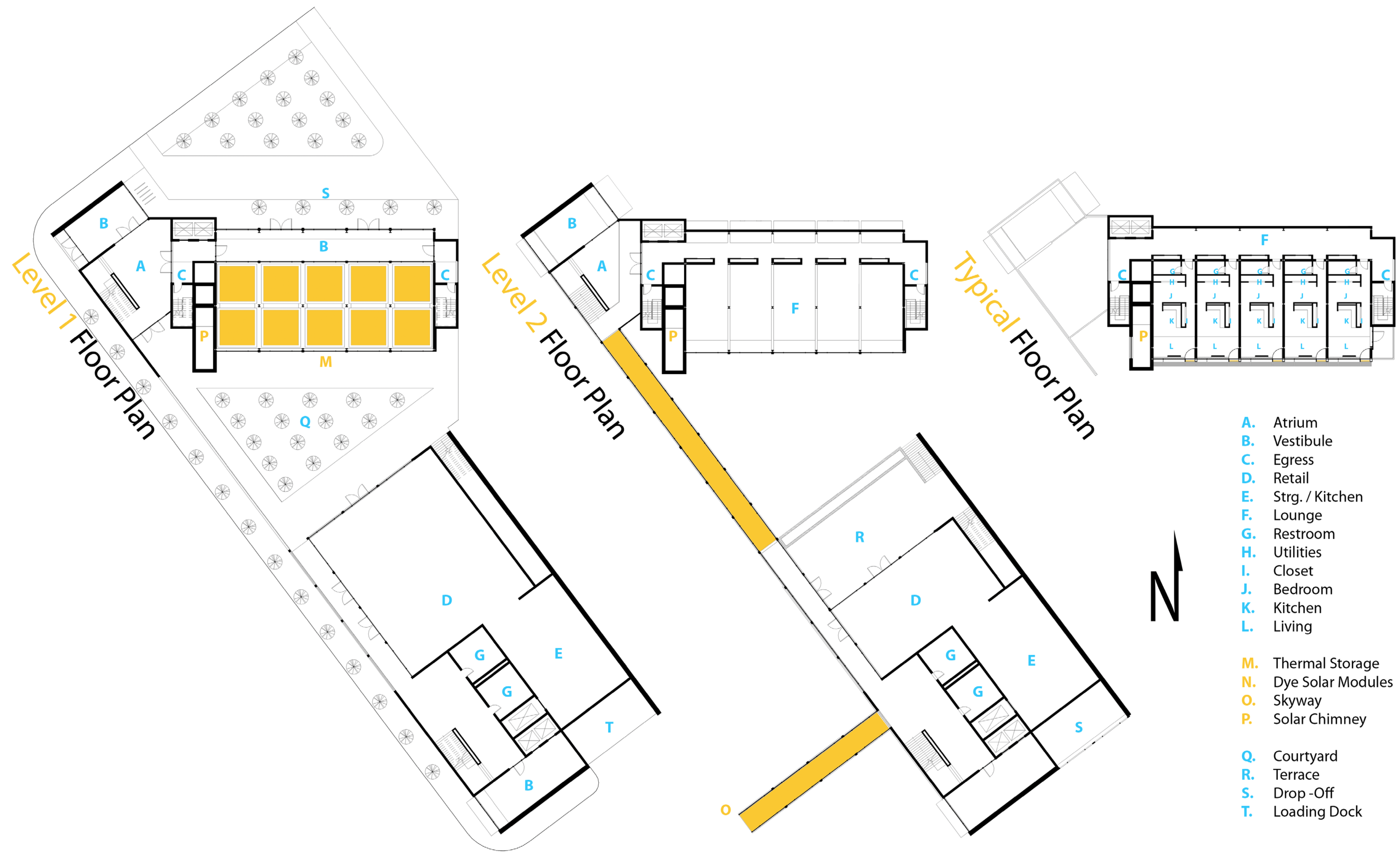
High performance buildings are achieved not only through the exploration of both passive & active systems in early stages of design, but by adapting & changing these systems as the design evolves. All components and objectives of the design must be held in proper balance throughout the design process as spaces and form begin to take shape.

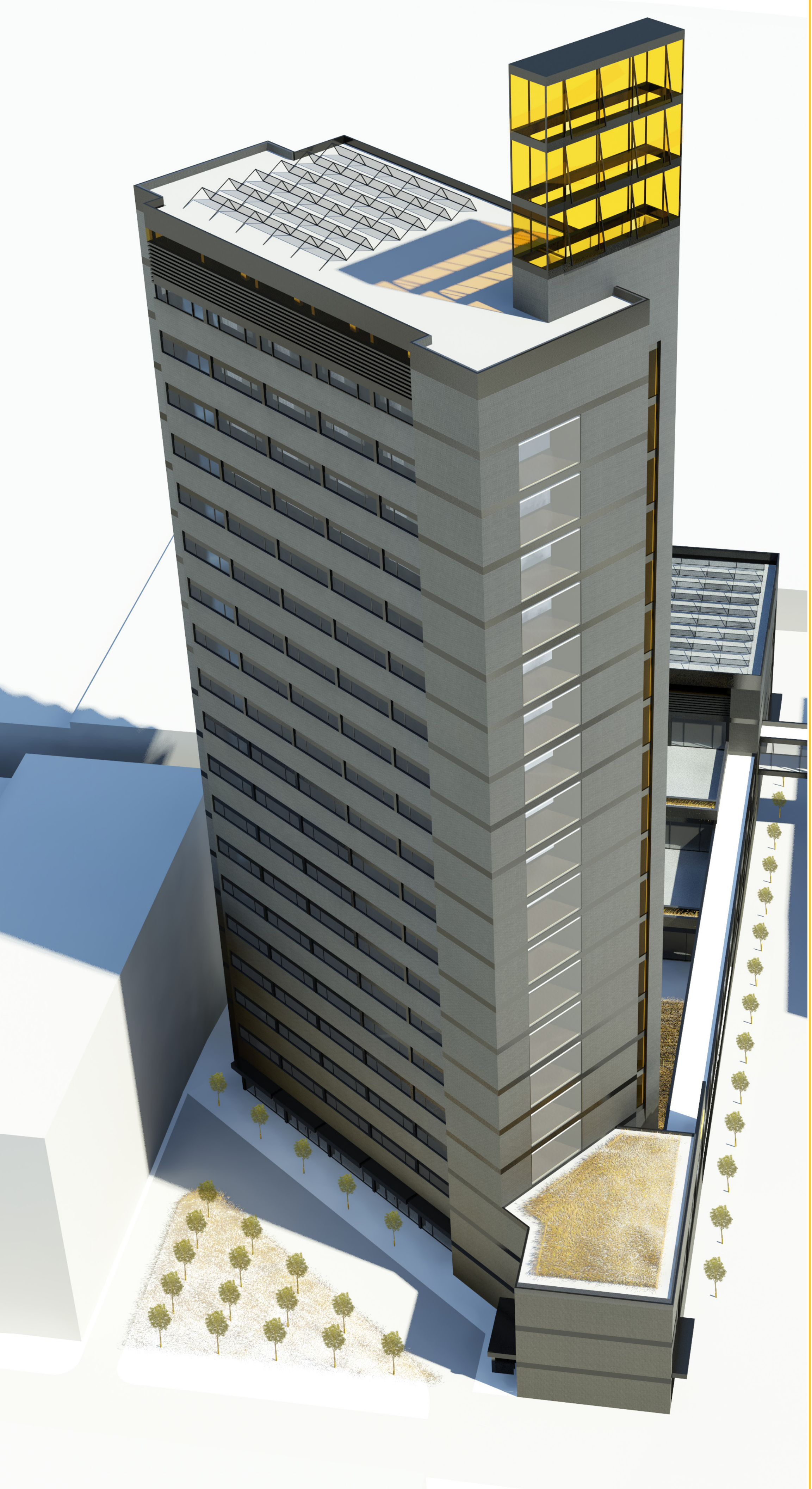
DESIGN PROCESS & METHODOLOGY



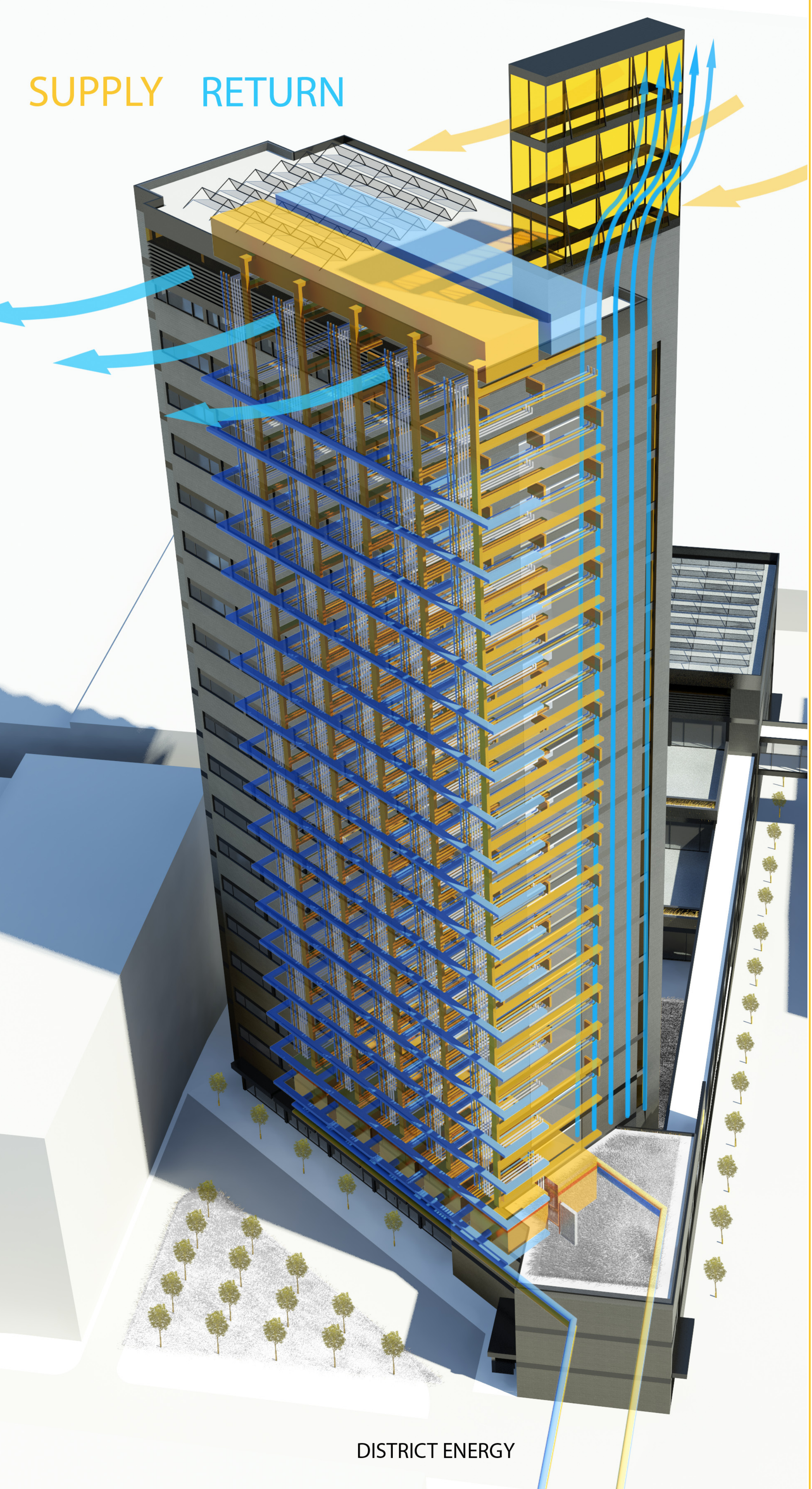


PLANS | PROGRAMMING

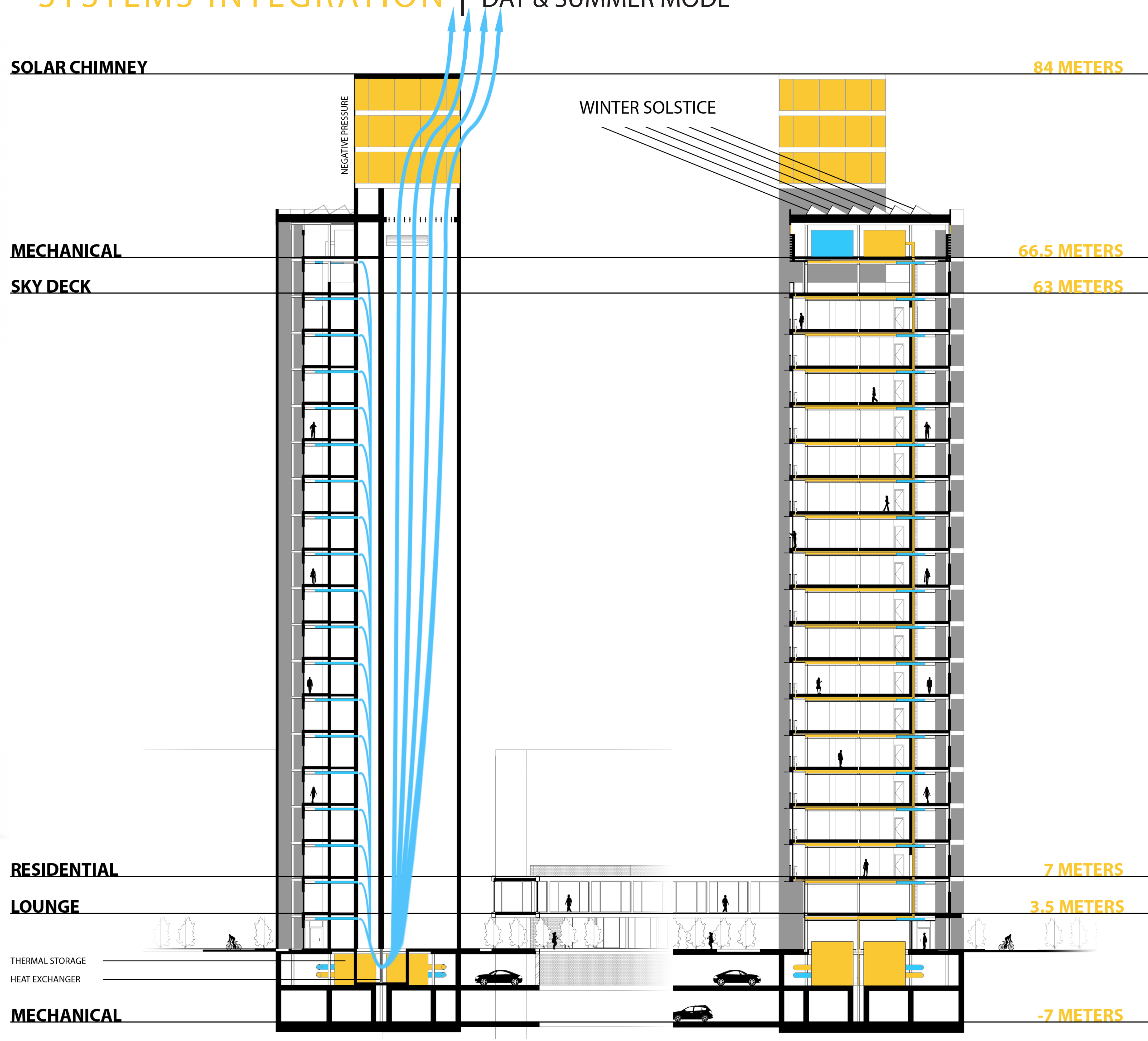


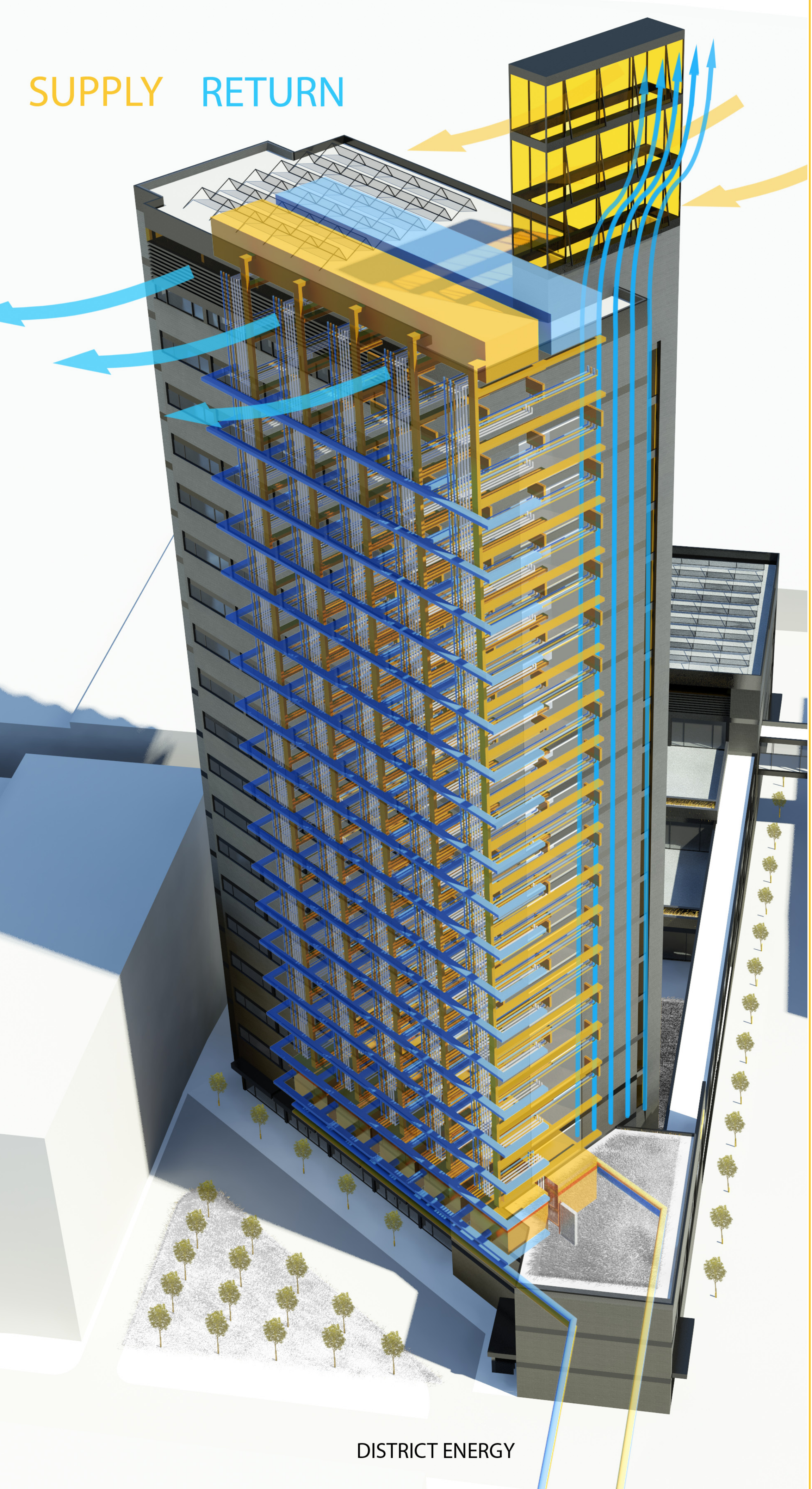


SYSTEMS INTEGRATION | WINTER & NIGHT MODE

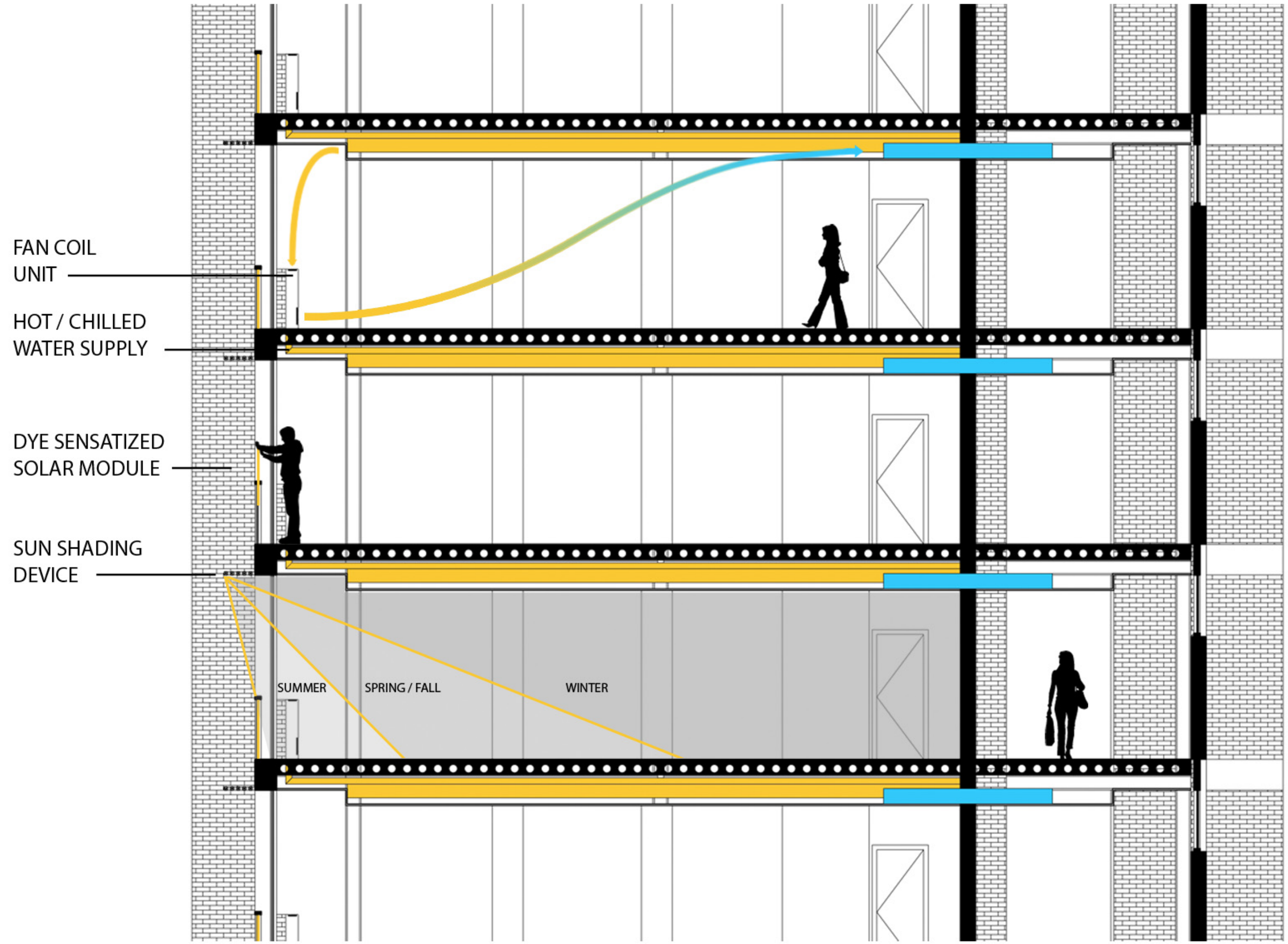


SYSTEMS INTEGRATION | DAY & SUMMER MODE

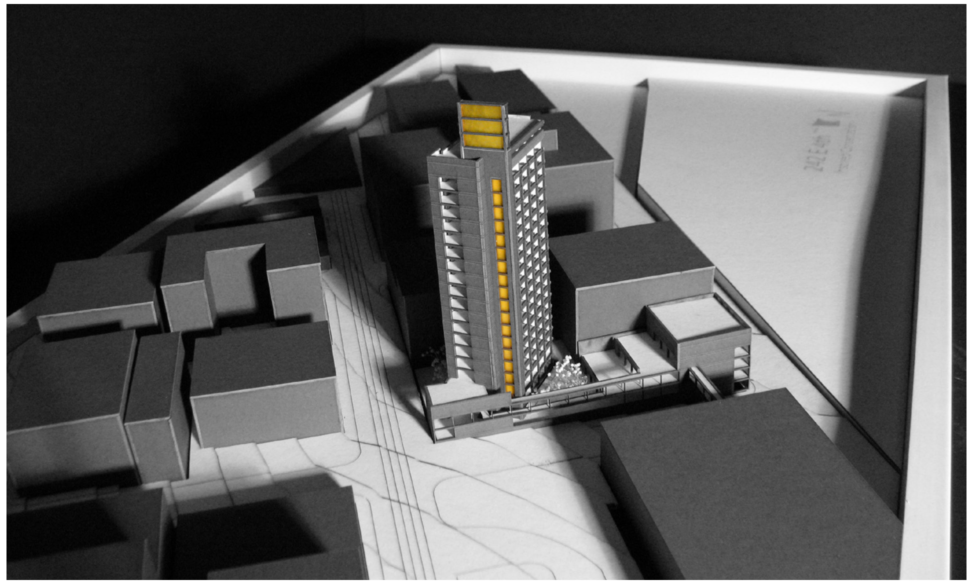


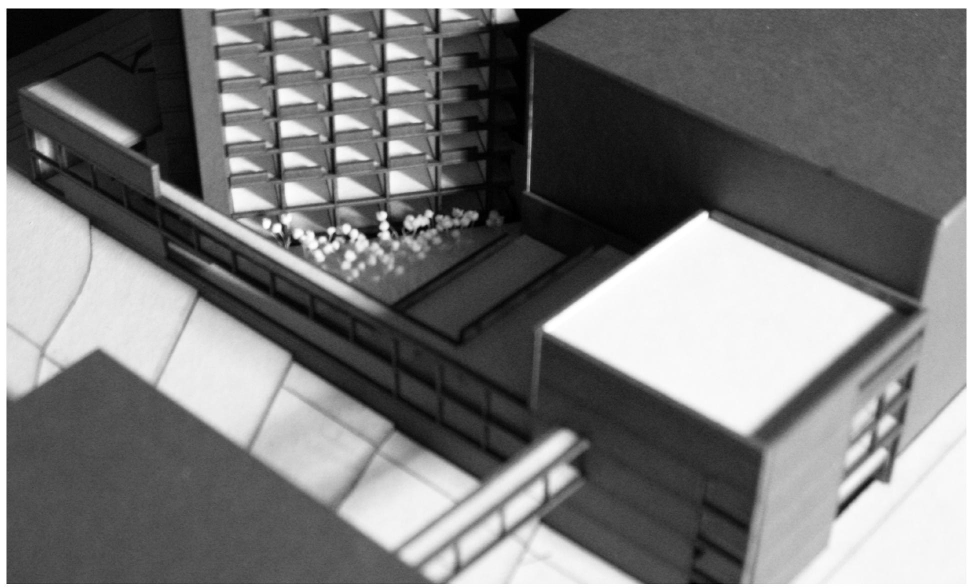


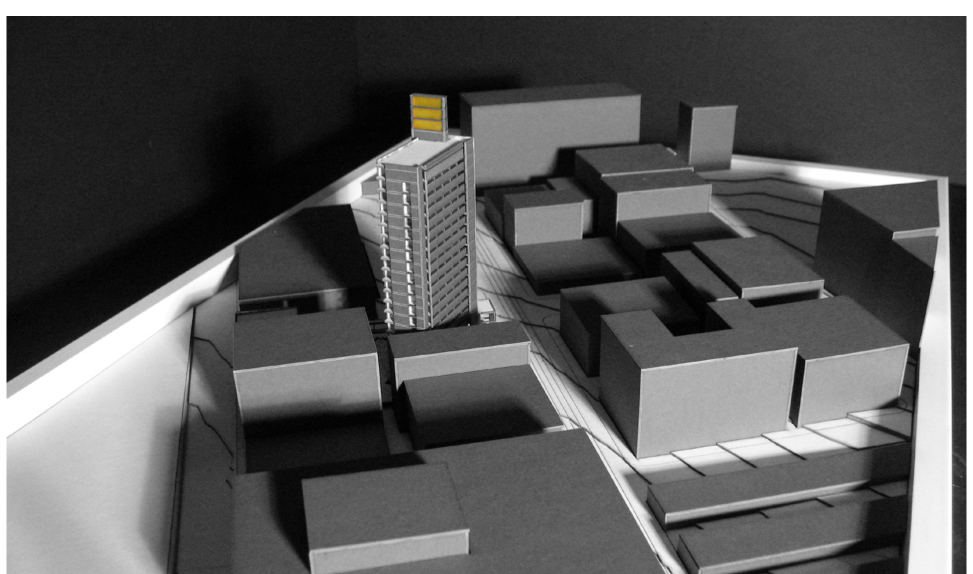
SYSTEMS INTEGRATION | RESIDENTIAL UNITS



MODEL DOCUMENTATION

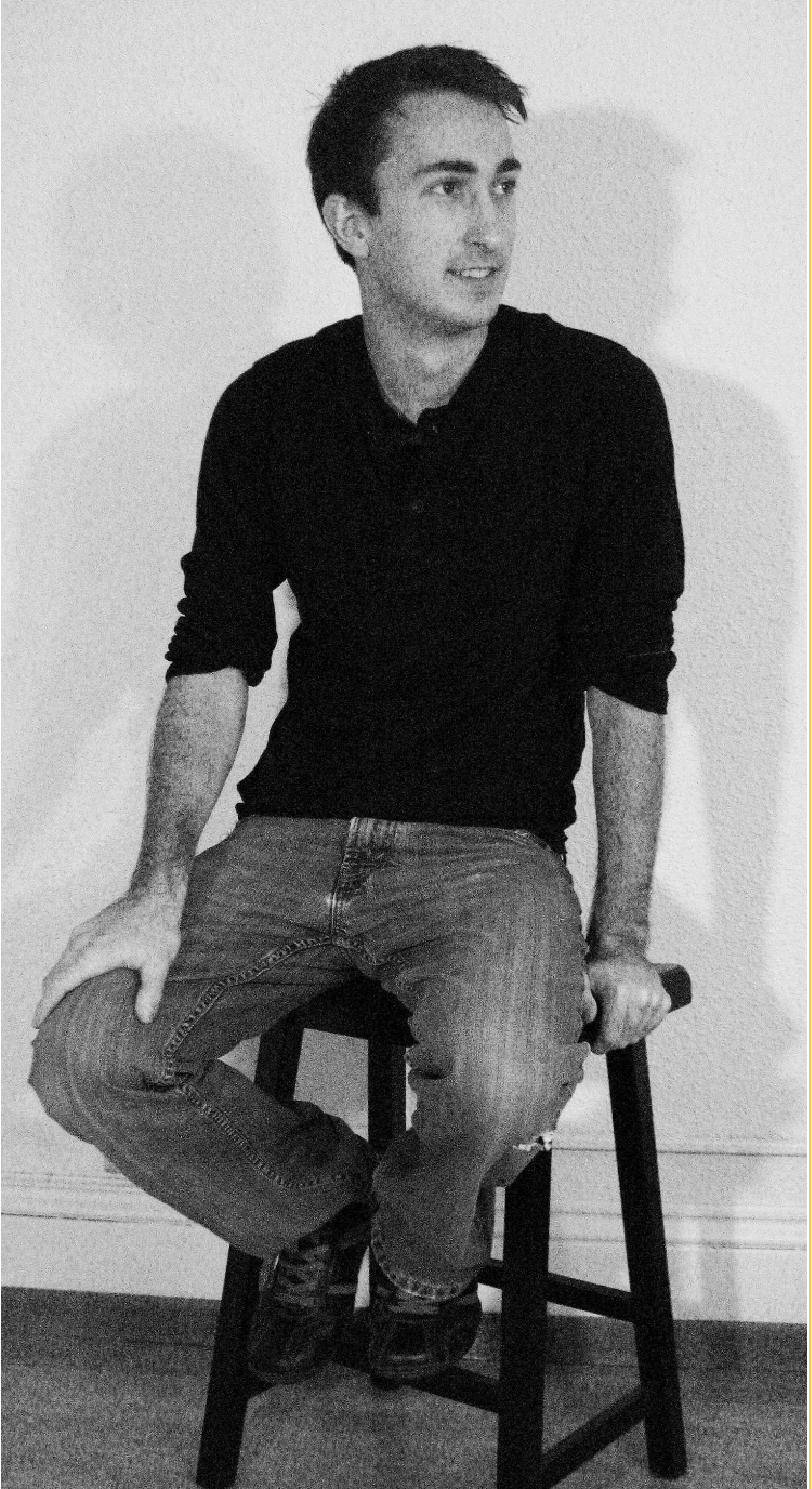






CONCLUSION

Exposing the passive and active systems and adjusting for optimal solar orientation provides a reminder to the public and its inhabitants that this building is going to lengths to conserve and manage the energy it uses, and by example shows people that they should do the same. This proposal for a mixed-use building will become an expression of energy conservation while serving as an extension of St. Paul's transportation and energy infrastructure and preserving the city's historical significance.



PERSONAL IDENTIFICATION

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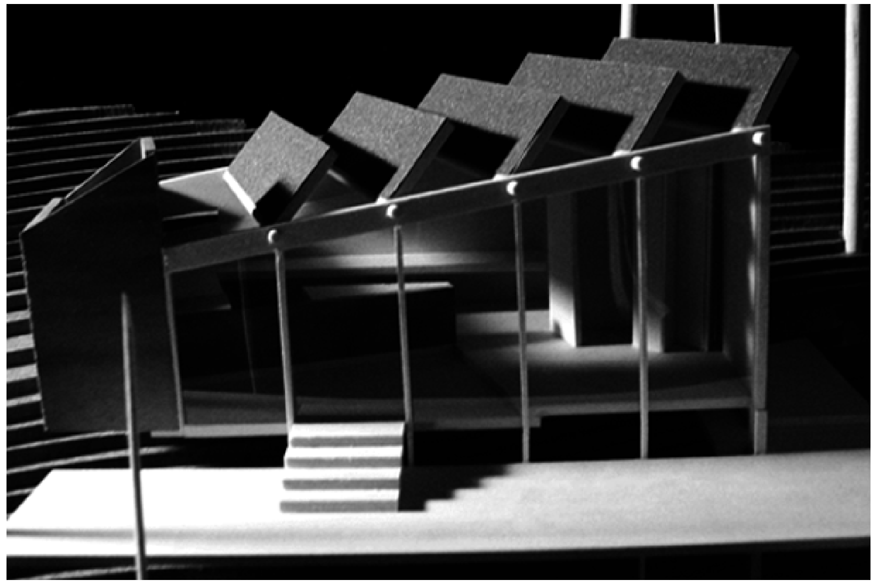
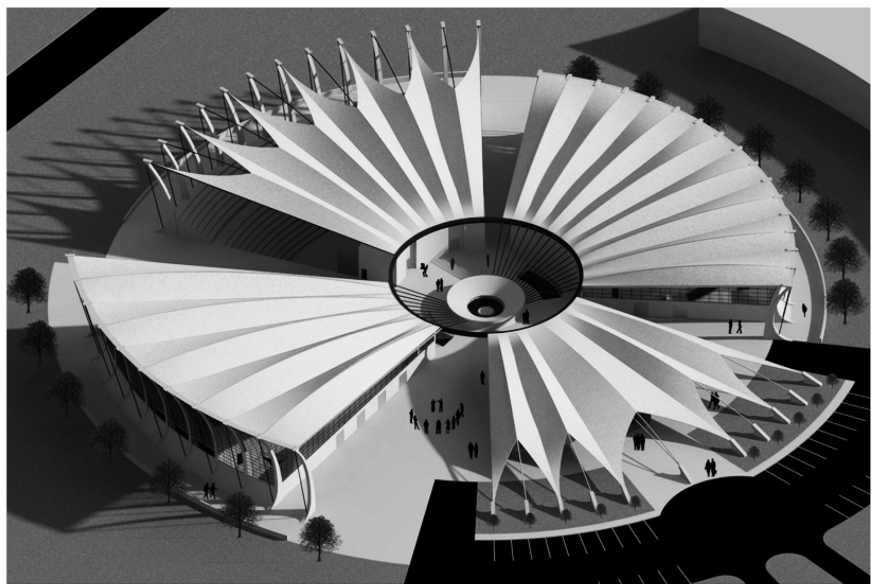
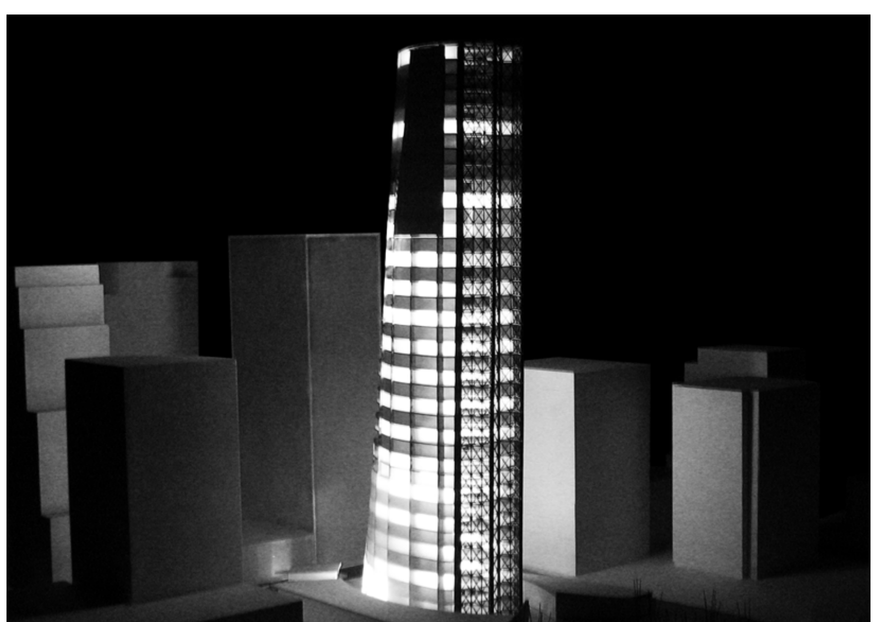
nkirscht@hotmail.com

7481 54th St. N
Oakdale, MN 55128

"Genius is 1% inspiration and 99% perspiration" | Thomas Edison







PREVIOUS STUDIO EXPERIENCE

DESIGN FUNDAMENTALS
ENVD 172
Professor Steven Whischer
| Inline Movement
| Warmth
| Perfectionist

SECOND YEAR DESIGN STUDIO
ARCH 271
Professor Darryl Booker
| Tea House
| Boathouse
| Biohaus

ARCH 272
Professor Mike Christenson
| Multi-Family Community

THIRD YEAR DESIGN STUDIO
ARCH 371
Professor Steve Martens
| Research Facility
| Mason's Guild

ARCH 372
Professor David Crutchfield
| Performing Arts Center
| Hotel for Space Center

FOURTH YEAR DESIGN STUDIO
ARCH 471
Professor Bakr Alyahmed
| High-Rise

ARCH 472
Professors Daryl Booker, Frank Kratke,
& Paul Gleye
| Livingston School
| Community Redevelopment

ADVANCED ARCH DESIGN
ARCH 571
Professor Mark Barnhouse
| Water Research Facility

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